A STUDY TO INCREASE PARTICIPATION OF HABITAT FOR HUMANITY AFFILIATES IN LEED FOR HOMES CERTIFICATION

A Thesis

by

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ABSTRACT

In the United States, Habitat for Humanity is at the forefront of the providing affordable housing to low income homeowners. Because of this work, Habit for Humanity is one of the leading homebuilders in the United States. A recent development in the assessment of home building is an increased emphasis on the use of technology and methods that reduce the impact of housing construction and occupation on the world's environment. Numerous methods exist to assess this impact, a major one in the United States is the LEED system developed by the US Green Building Council. Two problems exist with the LEED system, one being cost and the time of preparation of the necessary paperwork. Other research work exists on these implementation problems for the broader community, but this study looks at the specific impact and impediments to obtaining LEED certification for Habit for Humanity housing, specifically in Texas. This study assesses Habit for Humanity affiliate's involvement with LEED and sustainable building. This is accomplished in two parts, a survey and an analysis of LEED scorecards. To gauge the current state of sustainable building in Habitat for Humanity affiliates of Texas a survey was conducted. There were 15 participants out of 84 affiliates. The survey looked in to the current sustainable practices and barriers for the affiliates to participate in the LEED program. Then LEED score cards were obtained and analyzed, eleven scorecards total were obtained. Six scorecards were from homes built by Habitat for Humanity affiliates across the United States, and

the other five scorecards came from a production home builder in Texas. The scorecards were then compared by determining the mean of points for each question.

From this case study, the survey shows cost and knowledge to be the largest barriers to LEED certification. The data from the LEED scorecards showed Water Efficiency and Indoor Environmental Quality to be the two weakest categories for the HFH affiliates compared to the production homes. These barriers can potentially be overcome by the availability of grants for sustainable building and by educating the affiliates on LEED and sustainable building. The fact that HFH is a leader in affordable housing means if HFH affiliates can build to LEED standard so can other affordable builders.

DEDICATION

This thesis is dedicated to my parents and Grant. Thank you for all of your support.

ACKNOWLEDGEMENTS

I would like to thank my committee chair, Dr. Boong Yeol Ryoo, and my committee members, Dr. John Nichols and Dr. Weiling He. I would not have been able to complete this thesis without their guidance and help, through the process. I would also like to acknowledge the help of the Habitat for Humanity affiliates who sent me LEED scorecards and the ones who answered my survey.

NOMENCLATURE

AMI	Average Median Income
B/CS	Bryan/College Station
HaH	Habitat for Humanity
HUD	Housing and Urban Development Department
LEED	Leadership in Energy and Environmental Design
USGBC	US Green Building Council

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CHAPTER I

INTRODUCTION

BACKGROUND

Currently there is a shortage of affordable housing in the country. A study by Harvard's Joint Center for Housing showed 20.2 million households pay more than half of their income to housing Joint Center for Housing, 2012 (The Joint Center for Housing Studies of Harvard University, 2012). Affordable housing is defined as housing which costs a maximum of 30% of a low income family's income (U.S. Department of Housing and Urban Development, 2001). Organizations such as Habitat for Humanity work with low income families and use the Department for Housing and Urban Development's (HUD) definition of low income. This definition uses a formula based on the median income of the local area and household size. For each household of any income range the affordability of housing is based on many factors such as family size, family income, home size, and area income.

Providing affordable housing is not always easy. There are communities with restrictions in place which are used to prevent low income individuals from living in the area. Low income is roughly defined by a household having 80% or less of the average median income (AMI), and moderate income is between 81-120% AMI (U.S. Department of Housing and Urban Development, 2001). Another problem is the cuts to government programs that provide subsidies for families. However, there is still affordable housing being built.

The government is building public housing, and community organizations like Habitat for Humanity (HFH) are focused on providing affordable housing. Some commercial builders are also taking advantage of government subsidies, so it is profitable for them to build for low and moderate income families.

Affordable housing is necessary to society. It has been shown that affordable housing creates better outcomes for children in school due to the stability of living in one place (Mueller & Tighe, 2007). Mueller and Tighe also found that stable home environment reduced the stress of everyone living in affordable housing, as compared to a situation that was not affordable and overcrowded.

While affordable housing can negatively affect property values, this only occurs when the homes are poorly designed and maintained. Nguyen (2005) found affordable housing only affected property values through design and maintenance, concentration of affordable housing, and compatibility in the neighborhood. Another factor in negative impact on property values is whether or not the homes are placed in economically disadvantaged areas, and if the housing is clustered together. However it was found that homes that are maintained, designed well, and built in a vibrant area do not affect the property values in the surrounding neighborhoods (Nguyen, 2005).

One of the factors that determine affordability of housing is the cost to maintain and operate the home, which is primarily influenced by the energy consumption. This means a house with a lower utility bill is more affordable than a house with a higher bill, when all other expenses are equal. Twenty per cent of the United States energy consumption occurs from residential housing demand. This translates to more than $160

billion in utilities bills per year agency 2008. These utilities bills can be the difference between a home being affordable and a home no longer being affordable. 40 million families do not have affordable housing, as of 2006 (U.S. Department of Housing and Urban Development, 2007). One way to make more homes affordable in the long term is to build them using sustainable energy usage and materials with a longer life span. One issue with building homes using more durable and sustainable materials is the increase in initial cost. However, more and more homes are being built using these materials and methods, while staying affordable.

There are many different benefits to using sustainable construction practices, and a major benefit is lowered utility bills by reducing energy usage (Kats, Alevantis, Berman, Mills, & Perlman, 2003). Some of the most vulnerable households have to spend 19% of their income on utilities (U.S. Department of Energy's Environmental Protection Agency, 2008c). However, it is estimated that households could save between 20-30% of their energy cost by using sustainable materials and practices. This savings could be the difference between affordable and no longer affordable housing to a family (Johnson Jr, 2007).

Another benefit is reducing air pollution. Having appliances that are energy efficient can reduce a household's CO2 output by 2 metric tons a year (U.S. Department of Energy's Environmental Protection Agency, 2008b). This is a significant difference, and when more and more homes reduce the CO2 output that can make an impact on the air pollution.

Homeowners will also benefit from these materials and methods by improving air quality. Improved air quality has been shown to decrease the incidence of cold and flu by 51% (Kats et al., 2003). The better building materials and methods can also increase the comfort level in a home. Proper insulation can reduce cold floors and drafty rooms and damp basements. Efficient windows can reduce condensation. This is a benefit because condensation can cause mold. The home can also increase in value due to the sustainable methods and materials (U.S. Department of Energy's Environmental Protection Agency, 2008a).

PROBLEM STATEMENT

Due to the shortage of affordable housing and the need to provide more sustainable housing, a standard should be developed for Habitat for Humanity. By developing these standards for Habitat for Humanity it is possible for other builders to use these standards to build sustainable affordable housing. The purpose of this study is to increase the participation of Habitat for Humanity affiliates in the LEED for Homes program. This study will look at the barriers for Habitat for Humanity affiliates to obtain LEED certification, and analyze the scorecards for Habitat for Humanity homes, which have LEED certification.

METHODOLOGY

To gauge the current state of Habitat for Humanity affiliates in Texas a survey was conducted. There were 15 participants out of 84 affiliates. The survey looked in to the current sustainable practices and barriers for the affiliates to participate in the LEED program. Then LEED scorecards were analyzed and 11 scorecards total were obtained.

Six scorecards were from homes built by Habitat for Humanity affiliates across the United States, and the other five scorecards came from a production homebuilder in Texas. The scorecards were then compared by determining the mean of points for each question.

THESIS ORGANIZATION

Section 1 looks at the background to the problem and the research objectives. Section 2 is a review of the related literature to this study. This will include literature on LEED for Homes, Habitat for Humanity, and Energy Star. Section 3 will look at the methodology used to collect the data. It will explain how the survey of Habitat for Humanity affiliates was conducted. The section will then continue with the guidelines used to rate LEED for Homes, and it will look at how the scorecards were collected. Section 4 will look at data collection, by looking at samples of the data collected. Section 5 analyzes the data collected. Trends will be determined from the survey, and LEED score cards will be compared to find the most common points earned. Section 6 provides the conclusions and recommendations for future work.

LIMITATIONS AND DELIMITATIONS

This paper is focusing on studying LEED participation of Habitat for Humanity affiliates in Texas. It then looks at how affiliates from different parts of the country have built their homes to LEED standards.

CHAPTER II

LITERATURE REVIEW

INTRODUCTION

The purpose of this chapter is to provide information about sustainable building, LEED and Habitat for Humanity and sustainable building. It also looks at sustainable building in the context of affordable housing.

The focus of sustainable building in the past has been on commercial construction, but within the past decade the focus has expanded to residential projects (Lockwood, 2006). In the past Leadership in Energy and Environmental Design (LEED) focused on the top 25% of the new home market (US Green Building Council, 2008a), but the organization is starting to actively pursue affordable housing (US Green Building Council, 2008b).

Sustainable building methods have been around for centuries, but the current movement has its roots in the oil crisis of 1973. Many people started to migrate out to the suburbs after World War II, but when the oil crisis hit people realized how the lifestyle was based on cheap energy. This realization leads to building based on responsible use of energy resources (Ding, 2008). The industry lost focus on this building method when oil prices dropped, but the focus is being regained due to current energy concerns.

Building a home using sustainable building methods improves the health of the durability, operating cost, environmental impact, and health of occupants without having

a significant increase to initial cost (US Green Building Council, 2008a). Connelly also argues the homes improved by sustainable building methods increase the pride of ownership and can help to end generational poverty.

LEED FOR HOMES

LEED for Homes is a rating system administered by, the US Green Building Council (USGBC), to verify the sustainability of residential homes. It is the residential credential for LEED. LEED was started in 1998, and has become the most dominate green rating system in the United States (Lockwood, 2006). LEED has been used as the standard for other countries developing sustainable building credentials (Castro-Lacouture, Sefair, Flórez, & Medaglia, 2009). The way LEED certifies buildings is by awarding points to a building based on criteria from different categories (Muse & Plaut, 2006).

In 2008, LEED for Homes was created to provide a more applicable rating system to residential homes. Reposa (2009) states that LEED for Homes has eight different categories:

- Innovation and Design
- Location and Linkage
- Sustainable Sites
- Water Efficiencies
- Energy and Atmosphere
- Materials and Resources
- Indoor Air Quality

- Awareness and Education

A maximum of 136 points can be earned with cutoffs at 45 (certified), 60 (silver), 75 (gold), and 90 (platinum) for each level of reached. The cost for certification can be between $1,050 and $2,350 (Reposa Jr, 2009).

LEED for Homes has started to focus on certifying more affordable homes (US Green Building Council, 2008b). HFH is an affordable home builder and ranked 6th in the United States for Builder 100, so some affiliates have had the opportunity to build LEED certified homes. HFH affiliates work with the USGBC by an affiliate to affiliate basis. Dallas HFH has been building all of its homes to LEED standards since 2008 (Dallas Area Habitats, 2012). The Austin affiliate has built a LEED Platinum home, and St. Louis has built 51 LEED Platinum homes (Habitat for Humanity International, 2012). The central Arizona affiliate has built a LEED Platinum home and 54 LEED Certified homes (Central Arizona Habitat for Humanity, 2011).

HABITAT FOR HUMANITY

Habitat for Humanity (HFH) is an ecumenical Christian housing ministry. It has affiliates all over the world, and in all 50 of the US states. HFH was founded by Millard and Linda Fuller in Americus GA. They created an organization that has built more than 400,000 simple decent affordable houses for low income first time homeowners, since its founding in 1976. Its operational headquarter is in Americus, GA and its administrative headquarter is located in Atlanta, GA. The affiliates work independently of HFH International, and the independence allows the affiliates to grow by their own rules. Homeowner families are selected on three different criteria: a need for affordable

housing, minimal amount of pre-existing debt, and an income between 30-60 % of the area's median income. Once selected, these homeowners agree to do sweat equity as a down payment for their house. During the sweat equity phase they go through the process of building a home, and working on other HFH families' homes. The time from application to receiving a key, should take no less than a year. HFH is the mortgage lender, and provides a zero percent interest mortgage to its homebuyers. The homebuyer is buying the home at cost and has a 30 year mortgage. HFH affiliates are able to operate through volunteer labor and donations of money and materials. HFH International has a policy of sustainable building, but it is not mandated for affiliates to comply. HFH on the whole is using LEED as a guideline for building its homes. Many affiliates are building homes from LEED certified to Platinum. A program called ReStore was developed and many affiliates now operate one. The ReStore is a home furnishing store that receives some of their products from deconstructing existing homes, rooms, or buildings. The policy at HFH is when the cost is not too great to pick the product that has the best life cycle, including environmental impact.

HFH receives many of their materials as gift-in-kind donations, others are paid for with donations, and some of the products paid for are discounted for HFH. HFH has a policy that if the upfront cost is not a significant increase the affiliate should choose the material that has the best life cycle value. While cost is an issue, Habitat does its best to procure environmentally friendly items to build their homes. Another consideration is how many points the house will receive on LEED certification. Many affiliates are starting to build LEED certified homes, or at least to the standard of LEED certified.

Habitat's sustainability plan is very much in line with LEED guidelines (Habitat for Humanity International, 2012).

HFH SUSTAINABILITY POLICY

HFHI does not have a sustainability policy that is mandatory for all affiliates. However, it does have sustainability guidelines that HFHI encourages all affiliates to strive towards in building green (Appendix A). HFHI has a sustainability guide which is posted on their website habitat.org. Since HFHI does not have a mandatory standard for affiliates to follow, each affiliate has their own policy when it comes to sustainability. The definition HFHI uses for sustainable building is "as providing housing for people with methods, products, and processes that create healthy homes and communities, are more durable, and conserve resources throughout construction and after (Habitat for Humanity International, 2012)." HFH's mission for building green homes is to lower the life cycle cost, lower monthly bills, and provide healthy environment. The design criteria are based on the size of the house with an emphasis on simple and decent. Some of the major points addressed by the design criteria were focused on making the homes accessible to people with mobility issues. When it comes to the site HFH recommends xeriscaping. It also encourages building the homes to Energy Star standards, so monthly bills will be lower. A water management plan and a waste management plan are also encouraged for all affiliates (Habitat for Humanity International, 2012).

SUMMARY

HFH has a mission to deliver low cost and affordable housing. The issue of developing green buildings is one of interest to this organization.

CHAPTER III

METHODOLOGY

INTRODUCTION

This chapter outlines the methods used for the study. The sections of this chapter are:

- Survey of Habitat for Humanity Affiliates
- Survey of LEED scorecards
- Guidelines for Habitat for Humanity Affiliate Survey
- Guidelines for LEED scorecards

SURVEY OF HABITAT FOR HUMANITY AFFILIATES

A short questionnaire was developed to find out what are the sustainability policies of the affiliates and what are barriers to the Habitat affiliates pursuing LEED certification. The questionnaire is three questions long and asks if the affiliate uses sustainable building methods, if they work with the local USGBC chapter, and what the barriers to building LEED certified are. Nearly 60 Habitat affiliates in Texas were contacted. The response rate was 25%. Once the data is collected, the responses were coded for key words to determine the common answers. USGBC chapters were contacted by phone or email based on a list of chapters that have worked with Habitat affiliates in the past. The questions will cover whether the chapter works with the local Habitat affiliates and if the chapter does anything specifically to attract Habitat affiliates. The survey is in Appendix II.

SURVEY OF LEED SCORECARDS

While USGBC has a database of LEED scorecards, for projects whose owners agree to make their scorecards public, LEED for Homes is not part of this database. The LEED scorecard is filled out for every LEED project, and it shows what sustainable methods were used for the home. Due to the lack of a central database of scorecards, 15 home builders were contacted through phone or email. Builders of affordable homes, custom homes, and government projects were contacted. These home builders included Habitat for Humanity affiliates and for-profit home builders with LEED certified homes. The expected response rate was 50% to my request for LEED scorecards from these home builders, but actual response rate was 75%. The home builders were Habitat for Humanity affiliates as well a production home builder. The builders were selected by number of homes built with LEED certification. Because the builders have multiple LEED homes, it was possible for the scorecards to be nearly identical to other LEED certified homes they have built. The type of home I am comparing are detached single family homes. The points for each project were placed into a spread sheet, and a statistical analysis was performed. The tables with the preliminary LEED scorecards are shown in Appendix A. These tables are broken up by the nine major categories in the LEED scorecard. The table came from the LEED for Homes checklist that list all of the possible points a home can receive as well as the maximum number of points attainable for each area. The columns of each of the tables are the names of the possible points, the maximum number of points possible. The analysis of all of the scorecards will consist of using mean and standard deviation on each question where it is applicable. This will

allow questions and answers to be analyzed for any patterns to determine what LEED points are common among different affiliates.

GUIDELINES FOR HABITAT FOR HUMANITY AFFILIATE SURVEY

The survey was created to find out the current state of the HFH ability to build to LEED standards. These questions were chosen to develop a benchmark on the affiliates sustainability policy, their interaction with USGBC, and their perception of barriers to obtaining LEED certification.

1. Does your affiliate have a green or sustainable building policy?

    If yes what is the policy and does it meet LEED requirements?

2. Do you work with the local USGBC chapter?

3. What are some barriers to certifying homes with LEED for your affiliate?

GUIDELINES FOR LEED SCORECARDS

Innovation & Design

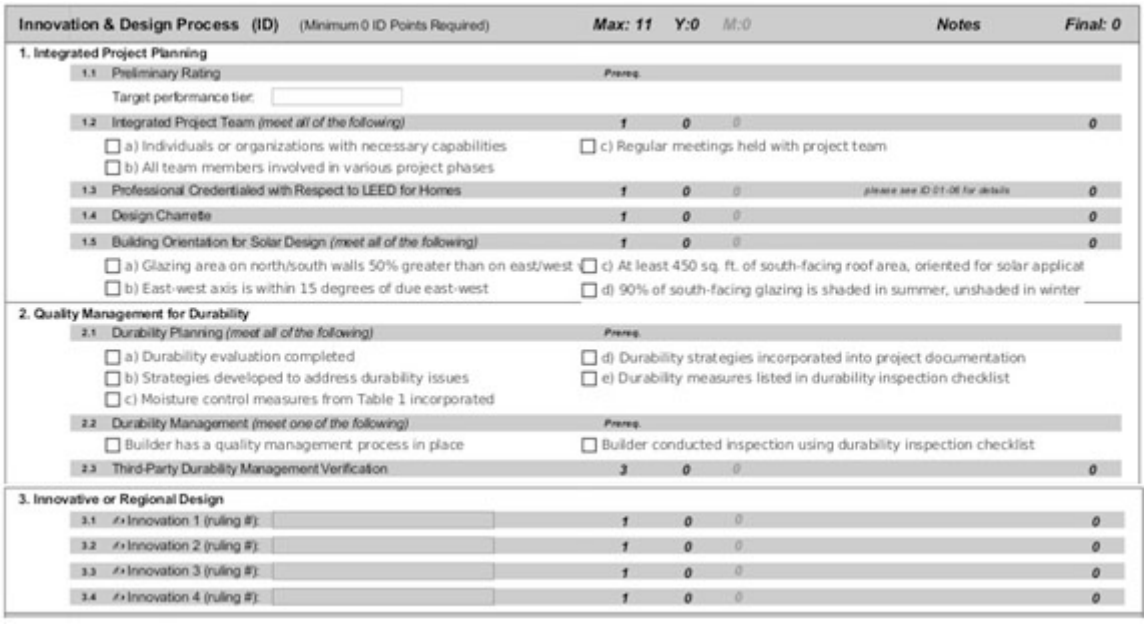
The first category, Integrated Project Planning, is intended to have a project with the best possible outcome of integrated, cost effective use of green technology and design. The first prerequisite in this category is the preliminary rating. This is given for having a LEED meeting as early as possible to target the LEED level, which credits the project intends to receive, and who is responsible for those LEED points. One of the points in their category is an integrated project team. The team must be skilled in areas of three of five criteria: building design, mechanical engineering, performance testing, green building and civil engineering. The team members must also be active participants of 3 of 7 phases: conceptual design, LEED planning, preliminary design, envelope

system analysis, design development, final design, and construction. Finally, monthly team meetings should occur unless the project is inactive.

The next point is given for having at least one full day of a design charrette with the team, preferably in the initial stages. The final credit of the first subsection is also given for the design of the home, such that the north and south facing walls have 50 % more glazing than the east and west facing walls. In coordination with glazing the east and west walls, orientation must be within 15 degrees of actual east and west. Another requirement is the roof has 450 square feet, which faces south and is suitable for solar panels. Finally, the glazing on the south end should be 90% shaded on the summer solstice and not shaded on the winter solstice. The next part to ID is a durability plan. The requirements of the durability plan are the Durability Risk Evaluation form, a plan to deal with risk found in the form, use all applicable moisture protection, document protection, and have a durability check-list in the documents.

A point is given for having the contractor mark off the durability check-list as the process is completed. Another point is given for having a Green Rater verify the check list. The third and final section of ID is for innovation or Regional design. This is to encourage using green design and technology that is beyond LEED standards.

Figure 1 shows the scorecard for innovation and design for LEED Homes.



Innovation & Design Process (ID) (Minimum 0 ID Points Required)	Max: 11	Y:0	M:0	Notes	Final: 0
1. Integrated Project Planning					
1.1 Preliminary Rating	Prereq.				
Target performance tier:					
1.2 Integrated Project Team *(meet all of the following)*	1	0	0		0
☐ a) Individuals or organizations with necessary capabilities ☐ b) All team members involved in various project phases ☐ c) Regular meetings held with project team					
1.3 Professional Credentialed with Respect to LEED for Homes	1	0	0	please see ID 01-06 for details	0
1.4 Design Charrette	1	0	0		0
1.5 Building Orientation for Solar Design *(meet all of the following)*	1	0	0		0
☐ a) Glazing area on north/south walls 50% greater than on east/west ☐ b) East-west axis is within 15 degrees of due east-west ☐ c) At least 450 sq. ft. of south-facing roof area, oriented for solar applicat ☐ d) 90% of south-facing glazing is shaded in summer, unshaded in winter					
2. Quality Management for Durability					
2.1 Durability Planning *(meet all of the following)*	Prereq.				
☐ a) Durability evaluation completed ☐ b) Strategies developed to address durability issues ☐ c) Moisture control measures from Table 1 incorporated ☐ d) Durability strategies incorporated into project documentation ☐ e) Durability measures listed in durability inspection checklist					
2.2 Durability Management *(meet one of the following)*	Prereq.				
☐ Builder has a quality management process in place ☐ Builder conducted inspection using durability inspection checklist					
2.3 Third-Party Durability Management Verification	3	0	0		0
3. Innovative or Regional Design					
3.1 Innovation 1 (ruling #):	1	0	0		0
3.2 Innovation 2 (ruling #):	1	0	0		0
3.3 Innovation 3 (ruling #):	1	0	0		0
3.4 Innovation 4 (ruling #):	1	0	0		0

Figure 1. LEED for Homes Scorecard for Innovation and Design

Location and Linkage

The next category is Location and Linkage (LL), which encourages building around communities and transit systems. A home that is in a Neighborhood Development receives all possible points for LL. LEED does not want to build on land that is below the 100 year flood plain, land that has endangered species, wetlands, previous public park land or land with soils of state significance. Points are awarded for the percentage of a site's border to developed land, with the benchmarks at 25% and 75%. LEED's preferred option is to build on a previously developed site.

LEED likes to encourage building homes that are close to resources by being within walking distance or having access to public transit. A point is awarded for being within half a mile of community resources and public transit. There are varying levels which account for the number of community resources and number of transit rides per

weekday. Another LEED advantage to building in the city as opposed to building in the suburbs is credits 5.1-5.3. The final subsection is access to an open space. Figure 2 shows the scorecard for Location and Linkage.

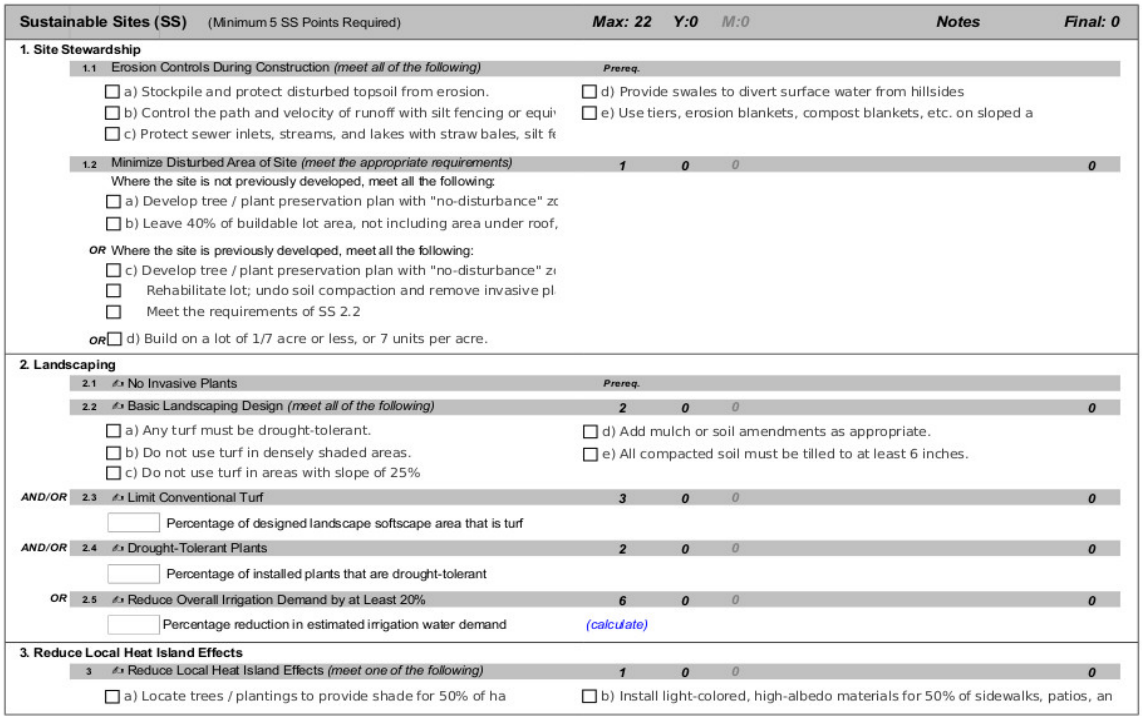
Location & Linkages (LL) (Minimum 0 LL Points Required)	Max: 10	Y:0	M:0	Notes	Final: 0
1. LEED for Neighborhood Development					
1 LEED for Neighborhood Development	10	0	0		0
2. Site Selection					
2 Site Selection *(meet all of the following)*	2	0	0		0
☐ a) Built above 100-year floodplain defined by FEMA	☐ d) Not built on land that was public parkland prior to acquisition				
☐ b) Not built on habitat for threatened or endangered species	☐ e) Not built on land with prime soils, unique soils, or soils of state signific				
☐ c) Not built within 100 ft of water, including wetlands					
3. Preferred Locations					
3.1 Edge Development	1	0	0		0
OR 3.2 Infill	2	0	0		0
AND/OR 3.3 Previously Developed	1	0	0		0
4. Infrastructure					
4 Existing Infrastructure	1	0	0		0
5. Community Resources / Transit					
5.1 Basic Community Resources / Transit *(meet one of the following)*	1	0	0		0
☐ a) Within 1/4 mile of 4 basic community resources	☐ c) Within 1/2 mile of transit services providing 30 rides per weekc				
☐ b) Within 1/2 mile of 7 basic community resources					
OR 5.2 Extensive Community Resources / Transit *(meet one of the following)*	2	0	0		0
☐ a) Within 1/4 mile of 7 basic community resources	☐ c) Within 1/2 mile of transit services providing 60 rides per weekc				
☐ b) Within 1/2 mile of 11 basic community resources					
OR 5.3 Outstanding Community Resources / Transit *(meet one of the following)*	3	0	0		0
☐ a) Within 1/4 mile of 11 basic community resources	☐ c) Within 1/2 mile of transit services providing 125 rides per weel				
☐ b) Within 1/2 mile of 14 basic community resources					
6. Access to Open Space					
6 Access to Open Space	1	0	0		0

*Figure 2***.** LEED for Home's Scorecard for Location and Linkage

Sustainable Sites

Construction has a large impact on the environment, whether it is tearing down habitats or creating new ones. The Sustainable Sites section deals with making sure the home has the best environmental impact possible. Its first subsection is site stewardship. This is to minimize the environmental impact on the lot. The prerequisite for this section is developing and implementing an erosion control plan during construction. This should include: protecting the soil for reuse, use silt fencing to control run-off, protect streams and lakes on site, divert surface ware away from the hillside, and stabilize soil

on the slopes which have been disturbed. Points are awarded for minimizing disturbances to the site as shown in Figure 3.



Sustainable Sites (SS) (Minimum 5 SS Points Required)	Max: 22	Y:0	M:0	Notes	Final: 0
1. Site Stewardship					
1.1 Erosion Controls During Construction *(meet all of the following)*	Prereq.				
☐ a) Stockpile and protect disturbed topsoil from erosion. ☐ b) Control the path and velocity of runoff with silt fencing or equi ☐ c) Protect sewer inlets, streams, and lakes with straw bales, silt fe ☐ d) Provide swales to divert surface water from hillsides ☐ e) Use tiers, erosion blankets, compost blankets, etc. on sloped a					
1.2 Minimize Disturbed Area of Site *(meet the appropriate requirements)*	1	0	0		0
Where the site is not previously developed, meet all the following: ☐ a) Develop tree / plant preservation plan with "no-disturbance" zo ☐ b) Leave 40% of buildable lot area, not including area under roof,					
OR Where the site is previously developed, meet all the following: ☐ c) Develop tree / plant preservation plan with "no-disturbance" z ☐ Rehabilitate lot; undo soil compaction and remove invasive pl ☐ Meet the requirements of SS 2.2					
OR ☐ d) Build on a lot of 1/7 acre or less, or 7 units per acre.					
2. Landscaping					
2.1 No Invasive Plants	Prereq.				
2.2 Basic Landscaping Design *(meet all of the following)*	2	0	0		0
☐ a) Any turf must be drought-tolerant. ☐ b) Do not use turf in densely shaded areas. ☐ c) Do not use turf in areas with slope of 25% ☐ d) Add mulch or soil amendments as appropriate. ☐ e) All compacted soil must be tilled to at least 6 inches.					
AND/OR 2.3 Limit Conventional Turf	3	0	0		0
☐ Percentage of designed landscape softscape area that is turf					
AND/OR 2.4 Drought-Tolerant Plants	2	0	0		0
☐ Percentage of installed plants that are drought-tolerant					
OR 2.5 Reduce Overall Irrigation Demand by at Least 20%	6	0	0		0
☐ Percentage reduction in estimated irrigation water demand	(calculate)				
3. Reduce Local Heat Island Effects					
3 Reduce Local Heat Island Effects *(meet one of the following)*	1	0	0		0
☐ a) Locate trees / plantings to provide shade for 50% of ha ☐ b) Install light-colored, high-albedo materials for 50% of sidewalks, patios, an					

Figure 3. LEED for Home's Scorecard for Sustainable Sites 1.1-3.1

Once the site is selected and landscaping is being the prerequisite of no invasive plants must be met. Additional points are given for drought tolerant plants; no turf is placed if there is dense shade or slope 25 %, adding mulch when necessary, and tilling the soil 6 inches. Limiting conventional turf is awarded 3 points on a scale. Another option is adding drought tolerant plants or reducing overall irrigation demand by 20%. The sustainable sites category also provides points for reducing the heat island effect by providing shading or reflectance on the paving.

The fourth subsection focuses on surface water management. This includes vegetative landscape, permeable paving, or direct run-off to an infiltration system as ways to earn points. Other points are earned through a retaining wall or plants, to prevent erosion, and rainwater harvesting. The fifth subsection is non-toxic pest control. Points are awarded for: leaving 12 inches between the wood and soil, sealing all penetrable areas, using metal or plastic to divide where wood meets concrete, and not planting anything within 24 inches of the home. Homes in termite areas receive points for non-toxic termite control. Figure 4 shows the scorecard for Sustainable Sites 4.1-6.3.

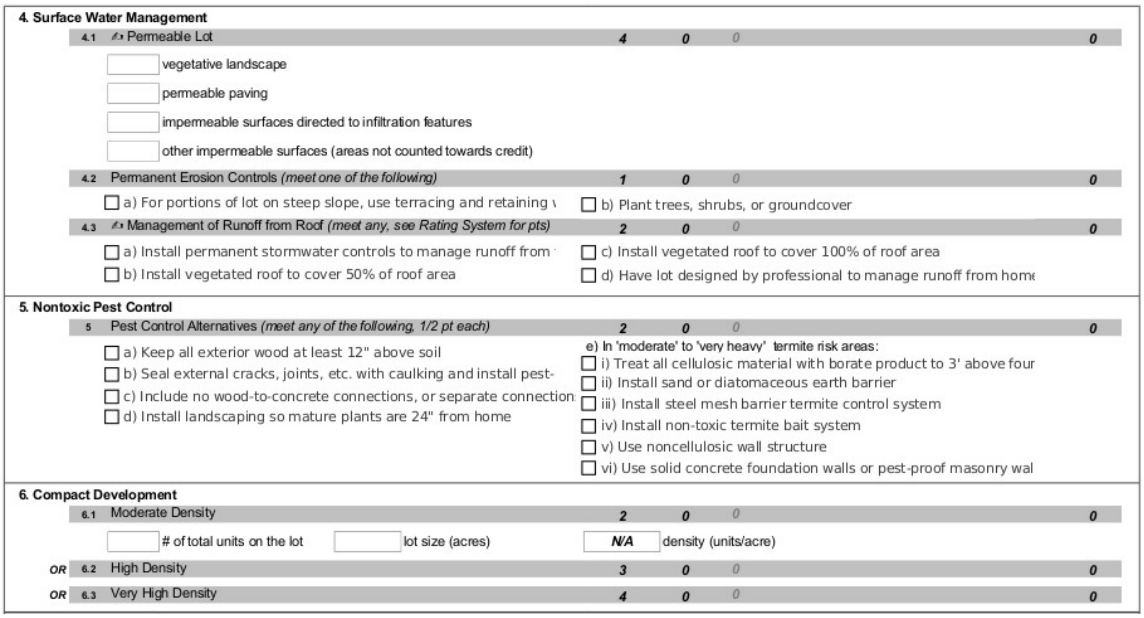


Figure 4. LEED for Home's Scorecard for Sustainable Sites 4.1-6.3

Water Efficiency

Water is a vital natural resource, so conserving water is a priority for LEED. Water reuse has a maximum of 5 points, which can be obtained through rainwater harvesting system (max 4 points) and/or grey water system (1 point), or the use of city

recycled water management program (3 points). Water irrigation systems hold a maximum of 4 points. High efficiency irrigation system: EPA water sense designed irrigation system, head to head coverage, central shut-off valve, sub meter, drip irrigation for 50 % of landscape, create watering zones based on watering needs, timer controller, pressure regulator, heads with a distribution uniformity of .7, check valves at head, and moisture sensor controls. Another point is awarded for having the irrigation checked by a third party. Another option is to reduce overall irrigation demand by 45%. 3 points are awarded for high efficiency fixtures and fittings or 6 points for very high efficiency. The difference being the lavatory fixture has ≤ 1.5gpm instead of 2.0 gpm, showers must be ≤1.75 gpm instead of 2.0, and toilets must be ≤ 1.1 gpf instead of 1.3 gpf. Figure 5 shows the scorecard for Water Efficiency.

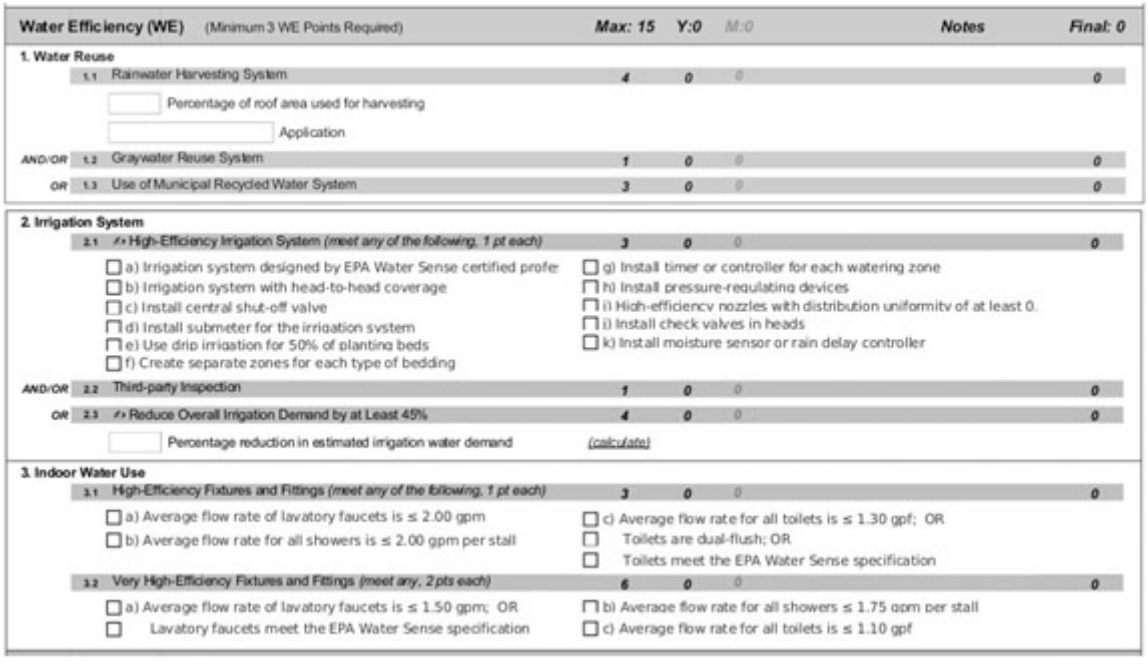
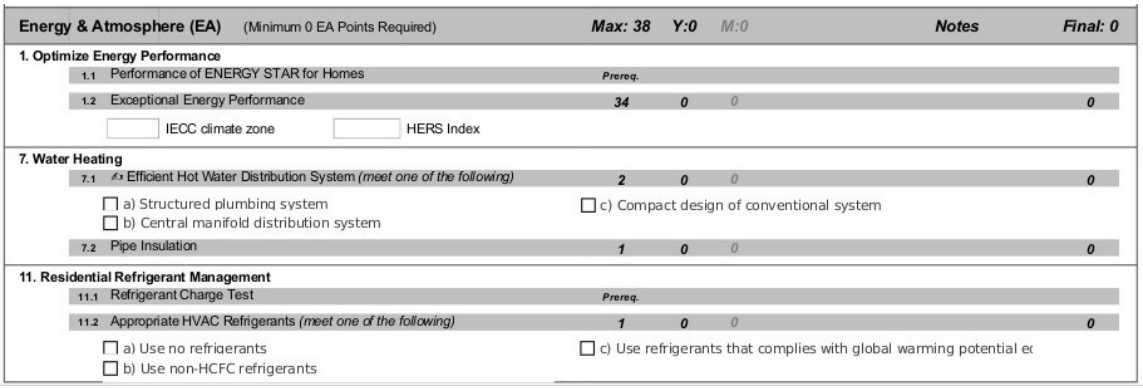


Figure 5. LEED for Home's Scorecard for Water Efficiency

Energy and Atmosphere

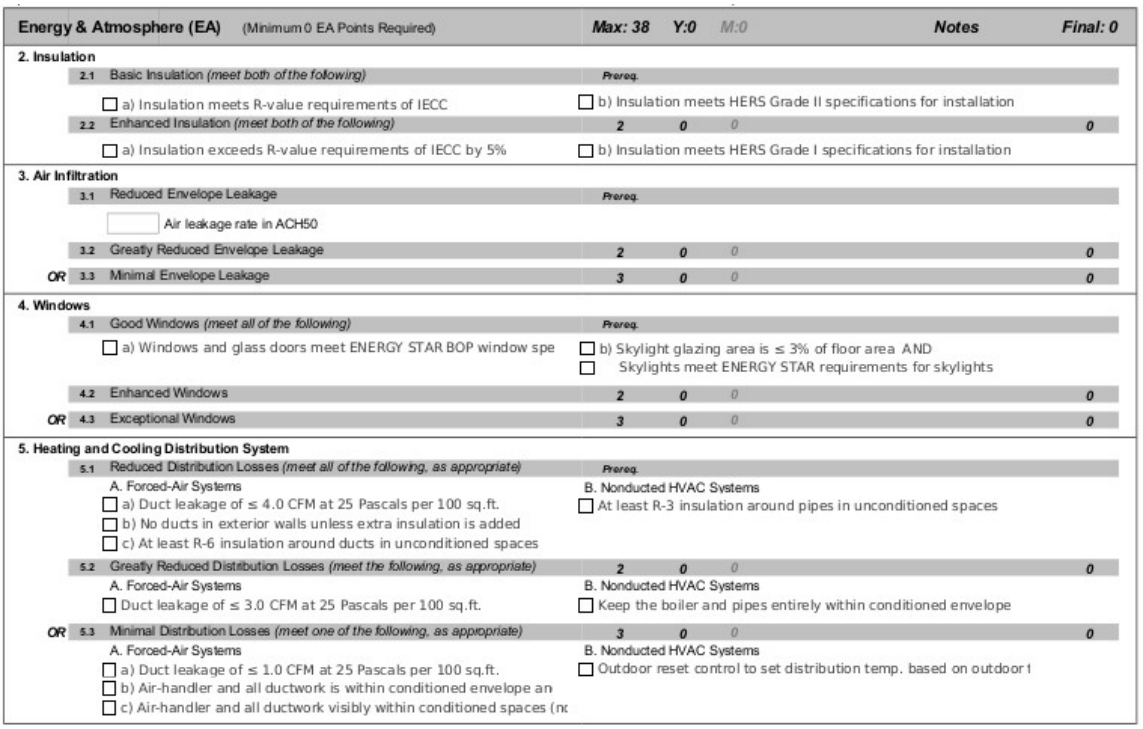
The fifth section is Energy and Atmosphere of the home. The first sub-section is about optimizing energy performance, and it is intended to make sure a home meets or exceeds energy star standards. The prerequisite for this credit (1.1) is to meet Energy Star standards. A maximum of 34 points can be added for having a HERS rating and exceeding energy star for homes performance. Credits for maximizing insulation to minimize heat transfer, can be up to 2 points.

Minimizing the air leakage earns a maximum of 3 points. The prerequisite is met by accomplishing and verifying the requirements. The requirements for receiving points for EA 3.2 and 3.3 are also in Table 3. Increasing the energy performance of the house by improving the windows can be a maximum of 3 points. The prerequisite for the points requires meeting energy star for homes national builder option package standards for windows. Other requirements include skylights not being more than 3% of floor space and a window to floor ratio of 18 % or greater must meet more stringent requirements. Points are earned for by installing more efficient windows, where 2 points is earned for 4.2 and 3 points for 4.3. Figure 6 shows the scorecard for Energy and Atmosphere credits 1.1, 1.2, 7.1, 7.2, 11.1, and 11.2. Credit for subsection 5, heating and cooling, requires the HVAC equipment and programmable thermostat should meet Energy Star regulations. It must also be designed using procedures equivalent to ACCA Manual J. 2 points are given for going above the requirements, and three points are given for going substantially above the requirements. Credit 6 is given for water heating, such as an efficient domestic hot water system as shown in Figure 7.



Energy & Atmosphere (EA) (Minimum 0 EA Points Required)	Max: 38	Y:0	M:0	Notes	Final: 0
1. Optimize Energy Performance					
1.1 Performance of ENERGY STAR for Homes	Prereq.				
1.2 Exceptional Energy Performance	34	0	0		0
☐ IECC climate zone ☐ HERS Index					
7. Water Heating					
7.1 Efficient Hot Water Distribution System *(meet one of the following)*	2	0	0		0
☐ a) Structured plumbing system ☐ b) Central manifold distribution system ☐ c) Compact design of conventional system					
7.2 Pipe Insulation	1	0	0		0
11. Residential Refrigerant Management					
11.1 Refrigerant Charge Test	Prereq.				
11.2 Appropriate HVAC Refrigerants *(meet one of the following)*	1	0	0		0
☐ a) Use no refrigerants ☐ b) Use non-HCFC refrigerants ☐ c) Use refrigerants that complies with global warming potential ec					

Figure 6. LEED for Home's Credits for Energy and Atmosphere # 1.1, 1.2, 7.1, 7.2, 11.1, and 11.2



Energy & Atmosphere (EA) (Minimum 0 EA Points Required)	Max: 38	Y:0	M:0	Notes	Final: 0
2. Insulation					
2.1 Basic Insulation *(meet both of the following)*	Prereq.				
☐ a) Insulation meets R-value requirements of IECC ☐ b) Insulation meets HERS Grade II specifications for installation					
2.2 Enhanced Insulation *(meet both of the following)*	2	0	0		0
☐ a) Insulation exceeds R-value requirements of IECC by 5% ☐ b) Insulation meets HERS Grade I specifications for installation					
3. Air Infiltration					
3.1 Reduced Envelope Leakage	Prereq.				
☐ Air leakage rate in ACH50					
3.2 Greatly Reduced Envelope Leakage	2	0	0		0
OR 3.3 Minimal Envelope Leakage	3	0	0		0
4. Windows					
4.1 Good Windows *(meet all of the following)*	Prereq.				
☐ a) Windows and glass doors meet ENERGY STAR BOP window spe ☐ b) Skylight glazing area is ≤ 3% of floor area AND ☐ Skylights meet ENERGY STAR requirements for skylights					
4.2 Enhanced Windows	2	0	0		0
OR 4.3 Exceptional Windows	3	0	0		0
5. Heating and Cooling Distribution System					
5.1 Reduced Distribution Losses *(meet all of the following, as appropriate)*	Prereq.				
A. Forced-Air Systems: ☐ a) Duct leakage of ≤ 4.0 CFM at 25 Pascals per 100 sq.ft. ☐ b) No ducts in exterior walls unless extra insulation is added ☐ c) At least R-6 insulation around ducts in unconditioned spaces	B. Nonducted HVAC Systems: ☐ At least R-3 insulation around pipes in unconditioned spaces				
5.2 Greatly Reduced Distribution Losses *(meet the following, as appropriate)*	2	0	0		0
A. Forced-Air Systems: ☐ Duct leakage of ≤ 3.0 CFM at 25 Pascals per 100 sq.ft.	B. Nonducted HVAC Systems: ☐ Keep the boiler and pipes entirely within conditioned envelope				
OR 5.3 Minimal Distribution Losses *(meet one of the following, as appropriate)*	3	0	0		0
A. Forced-Air Systems: ☐ a) Duct leakage of ≤ 1.0 CFM at 25 Pascals per 100 sq.ft. ☐ b) Air-handler and all ductwork is within conditioned envelope an ☐ c) Air-handler and all ductwork visibly within conditioned spaces (nc	B. Nonducted HVAC Systems: ☐ Outdoor reset control to set distribution temp. based on outdoor t				

Figure 7. LEED for Home's Credits for Energy and Atmosphere # 2.1-5.3

Two or more points are given for R-4 insulation on piping (6.2). Finally, 2 points are given for an efficient hot water distribution system (6.3). The options include a

structured plumbing system, central manifold distribution system, or compact design of conventional system. The compact design requires no branch line to exceed 20 ft. to any fixture for 1 story, and 20 ft. plus the height form floor to ceiling. The branch line from the header must be a maximum of 1/2 inch diameter, while a central manifold requires the trunk to be 6 ft. long and insulated to R-4 standards. The branches must meet the same standards as the compact system. The structured system must have the circulation pump insulated to R-4. The loop must be less than 40 ft. in one-storey or 40 ft. plus the height form floor to ceiling for each additional floor. Along with those requirements, branch lines must be 10 ft. and 1/2" diameter. Another requirement is there must be push button controls in full bathrooms and kitchens, and an automatic shut-off. A maximum of 3 points can be received for reducing the amount of energy from lighting. The prerequisite is to install at least 4 energy star light fixtures or CFLs in high-use areas. For an additional .5 points add 3 more light fixtures or CFLs, and 1 point is given for adding motion sensors for all exterior lights. Another option is to install Energy Star advanced lighting package or have 80 % of all light fixtures and all ceiling fans be Energy Star for the maximum 3 points. In order to reduce energy use by appliances 3 points is awarded for high efficiency appliances and water efficient clothes washers. High efficiency appliances are energy star refrigerators (1 point), ceiling fan (.5 points), dishwasher (.5 points), and clothes washer (.5 points). A clothes washer with a modified energy factor (MFE) 2.0 and a water factor (wf) of less than 5.5 receive an additional point. LEED gives 10 points for designing, modeling and installing a renewable electricity generator. 1 point is received for every 3 % in reduction from the annual reference electrical load.

This is determined in the 2006 Mortgage Institute National Home Rating Standards (HERS) guidelines. The last point in EA is for air conditioning and refrigerant. The prerequisite is proof of proper charge of the coolant. A point is earned by not using refrigerant, or using non-HCFC refrigerant, or the refrigerant should comply with equation (1):

$$LCGWP + LCODP * 10^5 \leq 160 \quad (1)$$

$LCODP$ is the lifecycle ozone depletion potential, in pounds of CFC_{11}/ton-year, as shown in equation (2):

$$LCODP = [D * (E * H + F) * G] / H \quad (2)$$

$LCGWP$ is the lifecycle direct global warming potential, in pounds of CO_2/ton-year, as shown in equation (3):

$$LCGWP = [C * (E * H + F) * G] / H \quad (3)$$

The symbols are the global warming potential of refrigerant, C , ozone depletion potential of refrigerant, D ,… refrigerant leakage rate, E ,.end of life refrigerant loss, F , refrigerant charge, G , and the equipment life, H .

Figure 8 shows the scorecard for Energy and Atmosphere credits 6.1-11.2.

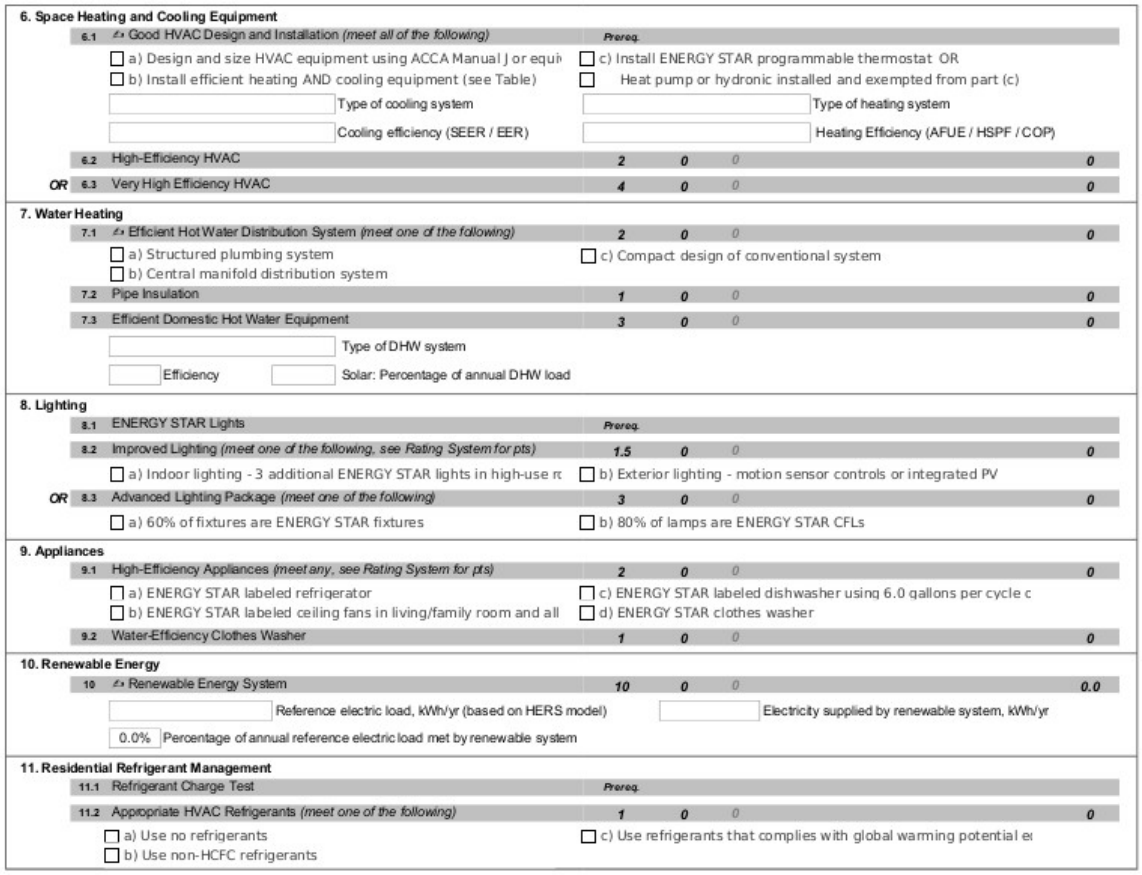


Figure 8. LEED for Home's Credits for Energy and Atmosphere # 6.1-11.2

Materials and Resources

Using materials efficiently is not only good for the environment but also the budget. The prerequisite requires no more than a 10 % waste factor (Table 6). This means a builder should not order more than 10 % of the specified framing material. Points are earned for having detailed framing documents, detailed cut list and lumber order, and efficient framing. A home can receive the full 4 points for framing off-site, instead of the previous 3 possible points.

To reduce some of the environmental impacts of materials, points are awarded for building with environmentally preferred products. The prerequisite requires the use of FCS wood for any tropical wood specified by the documents. This requires the supplier to be informed that all tropical wood must be FCS certified, and the contractor must request the woods' country of origin and a list of the FCS woods available. Using environmentally preferred products can earn a maximum of 8 points. The products can come from any of the three groups: environmentally preferred products, low emission, and low production. Each component from these categories is 0.5 points. The components are listed in.

Having a waste management plan can significantly reduce what ends up in a landfill. LEED requires the exploration of local options for waste diversion, which include soda bottles and cardboard. The diversion rates for all waste must be recorded and calculated. On top of those points 3 points are earned for producing no more than 2.5 pounds of waste. The points can also be earned by diverting a minimum of 25 % waste from landfills. Figure 9 shows the scorecard for the section Materials and Resources.

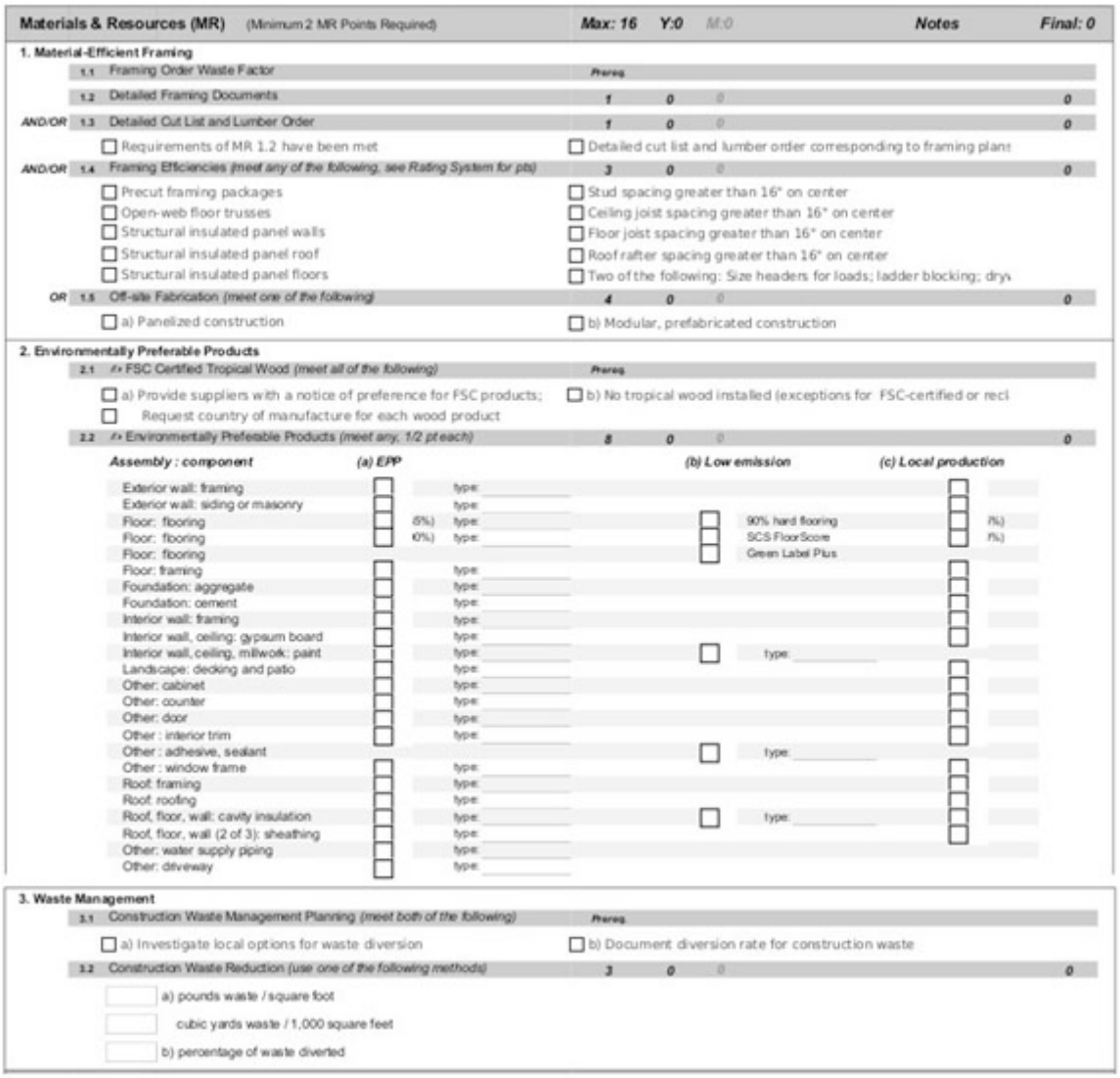


Figure 9. LEED for Home's Scorecard for Materials and Resources

Indoor Environmental Air Quality

Habitat wants to build a home that allows the home owner to succeed, and making sure the indoor air quality is a fresh as possible fits into that value. In LEED for homes there are two pathways for points in the Indoor Environmental Quality (EQ) section. One is through Credits 1, 4.2, 5.2, 5.3, 7.2/7.3, and 8.2. The other path skips the

first credit for Energy Star Indoor Air Package and focuses on the specific ways the home improves air quality. Installation of Energy Star Indoor Air Package earns 13 points.

Minimizing the leakage of combustible gasses to the home earns 2 points (2.1). The prerequisite is:

- No un-vented appliances
- Installation of a carbon monoxide monitor
- Doors installed on fireplace and wood stove
- Space heating must be closed combustion
- Power vented or outdoors

Additional points are given for fireplace and wood stove meeting. Figure 10 shows the scorecard for the section EQ credits 1 – 4.3.

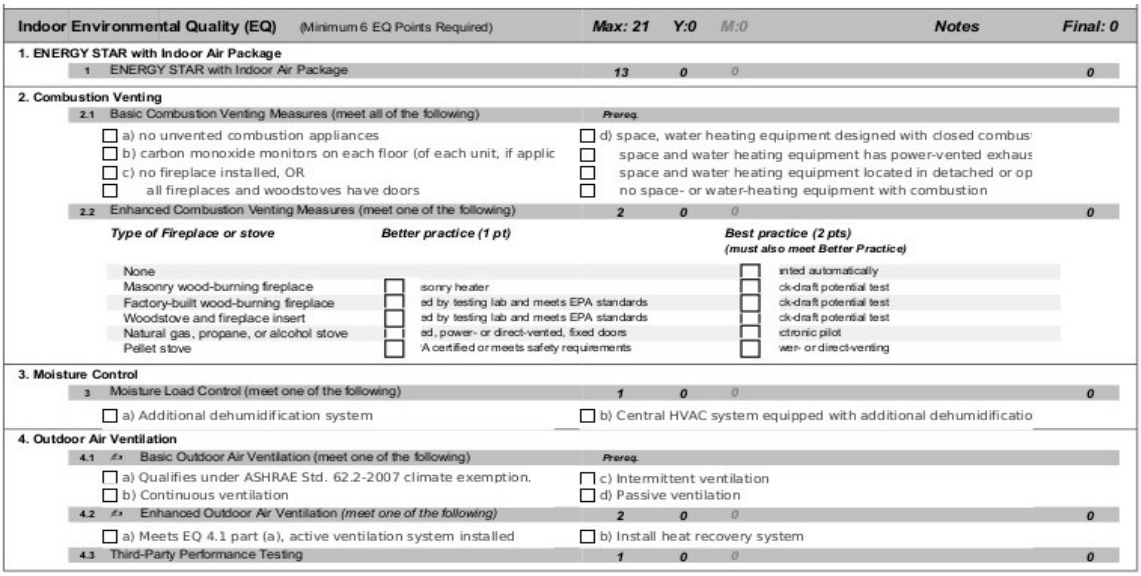
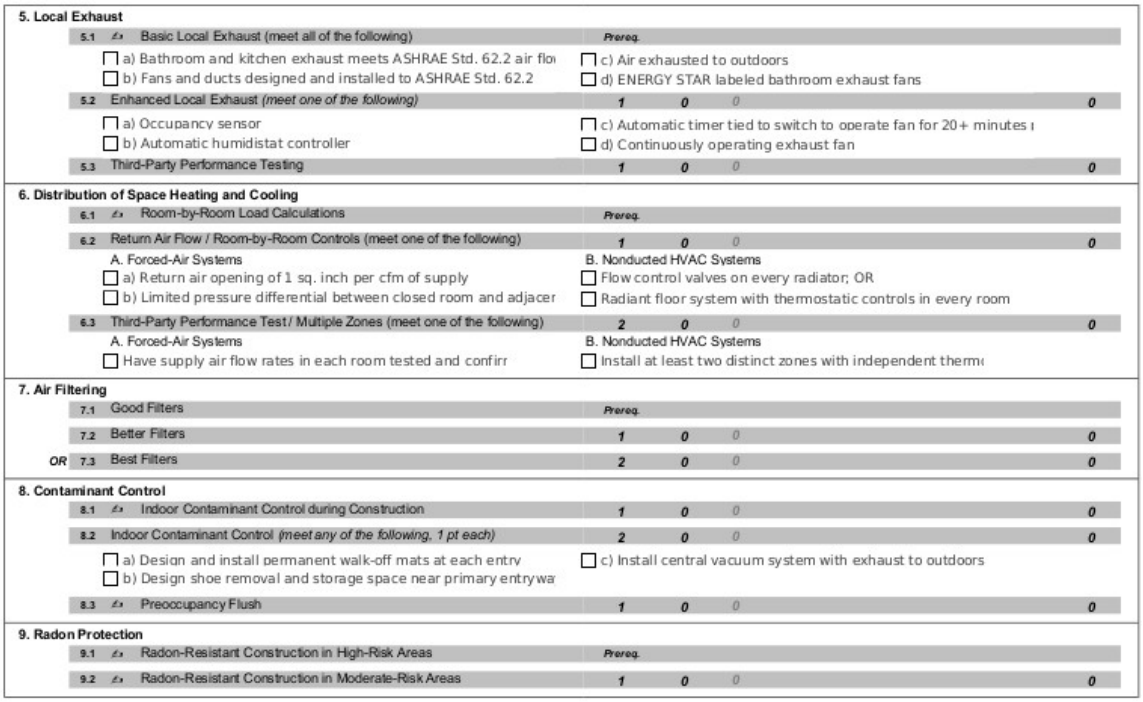


Figure 10. LEED for Home's Credits for Indoor Environmental Quality # 1.1-4.3

More points are earned for having a dehumidification system that allows for the home to stay below 60% humidity. LEED awards a maximum of 3 points for venting the house with outdoor air. The prerequisite is to have a ventilations system that meets the standards of ASHARE. Alternatives are available such as continuous ventilation or passive ventilation that meets the requirements in Table 7. An additional point is given for having a third party test the ventilation system. 2 points are awarded for either installing an active ventilation system in a home in mild climates, or a ventilation system that allows for heat transfer between indoor and outdoor air.

Reducing moisture and pollutants in the kitchen and bathroom receives 2 points after meeting the prerequisite. The prerequisite involves sending exhaust air to the outdoors, having Energy Star exhaust fans, exhaust systems that meets ASHARE standards (as shown in Table 8), and having fans and ducts to the same standard. 1 point is awarded for having any of the following: an occupancy sensor, or a humidistat controller, or timer, or a continuously running exhaust fan. Third party testing for these measures earns an additional point. Figure 11 shows the scorecard for the section EQ credits 5 – 9.2.



5. Local Exhaust						
5.1	Basic Local Exhaust (meet all of the following)	Prereq.				
	☐ a) Bathroom and kitchen exhaust meets ASHRAE Std. 62.2 air flo	☐ c) Air exhausted to outdoors				
	☐ b) Fans and ducts designed and installed to ASHRAE Std. 62.2	☐ d) ENERGY STAR labeled bathroom exhaust fans				
5.2	Enhanced Local Exhaust *(meet one of the following)*	1	0	0		0
	☐ a) Occupancy sensor	☐ c) Automatic timer tied to switch to operate fan for 20+ minutes				
	☐ b) Automatic humidistat controller	☐ d) Continuously operating exhaust fan				
5.3	Third-Party Performance Testing	1	0	0		0
6. Distribution of Space Heating and Cooling						
6.1	Room-by-Room Load Calculations	Prereq.				
6.2	Return Air Flow / Room-by-Room Controls (meet one of the following)	1	0	0		0
	A. Forced-Air Systems	B. Nonducted HVAC Systems				
	☐ a) Return air opening of 1 sq. inch per cfm of supply	☐ Flow control valves on every radiator; OR				
	☐ b) Limited pressure differential between closed room and adjacer	☐ Radiant floor system with thermostatic controls in every room				
6.3	Third-Party Performance Test / Multiple Zones (meet one of the following)	2	0	0		0
	A. Forced-Air Systems	B. Nonducted HVAC Systems				
	☐ Have supply air flow rates in each room tested and confirr	☐ Install at least two distinct zones with independent therm				
7. Air Filtering						
7.1	Good Filters	Prereq.				
7.2	Better Filters	1	0	0		0
OR 7.3	Best Filters	2	0	0		0
8. Contaminant Control						
8.1	Indoor Contaminant Control during Construction	1	0	0		0
8.2	Indoor Contaminant Control *(meet any of the following, 1 pt each)*	2	0	0		0
	☐ a) Design and install permanent walk-off mats at each entry	☐ c) Install central vacuum system with exhaust to outdoors				
	☐ b) Design shoe removal and storage space near primary entry wa					
8.3	Preoccupancy Flush	1	0	0		0
9. Radon Protection						
9.1	Radon-Resistant Construction in High-Risk Areas	Prereq.				
9.2	Radon-Resistant Construction in Moderate-Risk Areas	1	0	0		0

Figure 11. LEED for Home's Credits for Indoor Environmental Quality # 5.1-9.2

A maximum of 3 points is given for using the distribution systems that are appropriately sized for heating and cooling. When using a forced air system the first step is to have room-by-room by room load calculations completed.

Filtering the air is an important component to air quality. There are two different systems that can be used to filter air: forced air systems or non-ducted HVAC systems. The forced air system prerequisite requires the home to have filters with a minimum efficiency reporting value (MERV) with at least 8. Also the air pressure should be correct and the housing air tight. Additional points are given for higher MERV scores. The requirements are the same for non-ducted HVAC systems, except homes in a cooler climate and those with passive or exhaust only ventilation are exempt.

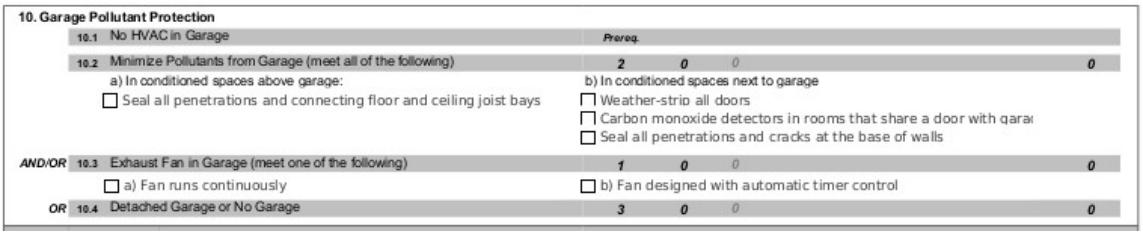
Reducing airborne contaminates makes the home healthier. The way a home is heated and cooled can affect occupants positively or negatively. Removing allergens and contaminants from the air by using filters can also have a huge impact on the occupants' lives. Points are provided for the contractors sealing off any permanent vents during construction to avoid contamination (1 point). To control contamination indoors install any of the following: a central vacuum system, a shoe rack at the entry for 2 pairs of shoes per room, and walk off mats at all the entries. Flushing the home with fresh air, which must be done after construction is complete and before the home is occupied, earns points. Another practice used to improve air quality is contaminate control. Radon can be a health issue, so homes in the EPA's radon zone 1 must follow the radon guidelines. Homes in the other zones receive an additional point.

In order to minimize the spread of pollutants a point is earned for no air conditioning in the garage. To avoid contaminating the indoor air all penetrations, floor joist bays, and ceiling joist bays are sealed and all walls are painted. Sealing all penetrations and cracks in any adjoining interior space, as well as weather stripping, earns additional points. A carbon monoxide detector and exhaust fan should also be installed. The fan should run continuously or have an automatic timer. The other option for the full three points is to build a detached garage. Figure 12 shows the scorecard for the section EQ credits 10.1 – 10.4.

Awareness and Education

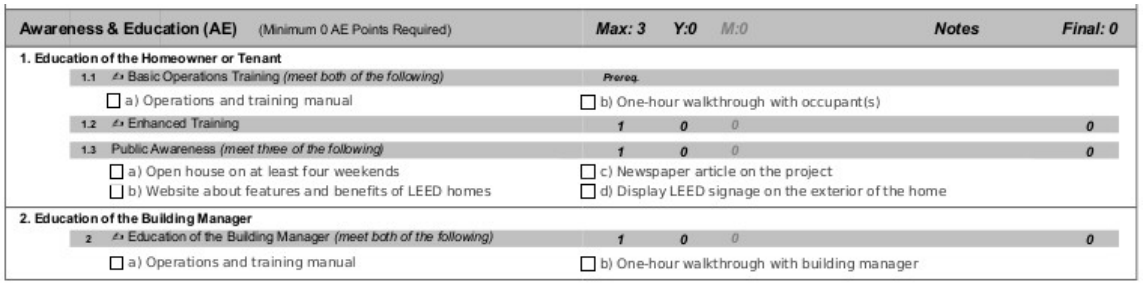
Educating the home-owner is a great way to make sure they know how to operate and maintain the home. For the section dedicated to awareness and education (AE), the

prerequisite credit is awarded for giving the homeowners a walk through, and providing them with an operations and maintenance manual. The manuals required contents are shown in Table 8. The rest of the credits in the first section are given for extra homeowner training and publicity of the project. Table 9 shows the possible ways to earn a credit for publicity. Finally, the last credit is awarded for providing building managers with the same packets as the homeowner. This credit focuses on multifamily homes with a minimum of 5 units. Figure 13 shows the scorecard for the section Awareness and Education.



10. Garage Pollutant Protection						
	10.1	No HVAC in Garage	Prereq.			
	10.2	Minimize Pollutants from Garage (meet all of the following)	2	0	0	0
		a) In conditioned spaces above garage: ☐ Seal all penetrations and connecting floor and ceiling joist bays	b) In conditioned spaces next to garage ☐ Weather-strip all doors ☐ Carbon monoxide detectors in rooms that share a door with gara ☐ Seal all penetrations and cracks at the base of walls			
AND/OR	10.3	Exhaust Fan in Garage (meet one of the following)	1	0	0	0
		☐ a) Fan runs continuously	☐ b) Fan designed with automatic timer control			
OR	10.4	Detached Garage or No Garage	3	0	0	0

Figure 12. LEED for Home's Credits for Indoor Environmental Quality # 10.1-10.3



Awareness & Education (AE) (Minimum 0 AE Points Required)			**Max: 3**	**Y:0**	M:0	**Notes**	**Final: 0**
1. Education of the Homeowner or Tenant							
	1.1	Basic Operations Training *(meet both of the following)*	Prereq.				
		☐ a) Operations and training manual	☐ b) One-hour walkthrough with occupant(s)				
	1.2	Enhanced Training	1	0	0		0
	1.3	Public Awareness *(meet three of the following)*	1	0	0		0
		☐ a) Open house on at least four weekends ☐ b) Website about features and benefits of LEED homes	☐ c) Newspaper article on the project ☐ d) Display LEED signage on the exterior of the home				
2. Education of the Building Manager							
	2	Education of the Building Manager *(meet both of the following)*	1	0	0		0
		☐ a) Operations and training manual	☐ b) One-hour walkthrough with building manager				

Figure 13. LEED for Home's Scorecard for Awareness and Education

CHAPTER IV

ANALYSIS OF RESULTS

INTRODUCTION

This chapter outlines the analysis of the results. The chapter includes the sections:

- Analysis of Affiliate survey
- Analysis of scorecards
    - Innovation and Design
    - Location and Linkage
    - Sustainable Sites
    - Water Efficiency
    - Energy and Atmosphere
    - Materials and Resources
    - Indoor Environmental Air Quality
    - Awareness and Education

ANALYSIS OF AFFILIATE SURVEY

The purpose of this survey is to understand the barriers for a Habitat for Humanity affiliates in Texas to build LEED certified or higher. After surveying 15 affiliates the data is leaning towards cost, accessibility to a green raters, and knowledge of LEED. When the affiliates were asked if they had a green or sustainable building policy most said they do not. However, most of the affiliates are building to Energy Star

standards. Some of them even stated they actively looked for the greenest products in the price range they can afford. The affiliates which stated they do have a sustainable building policy, which usually included Energy Star standards (Figure 14).

The next question determined how many affiliates have or are working with a USGBC chapter. None of the affiliates answered yes to working with a USGBC chapter, and 27% of the affiliates stated one of the reasons for this is their location in relation to the closest chapter. Many of the small affiliates of rural Texas do not have a USGBC chapter near them, because the USGBC chapters are all based out of the major cities in Texas- Dallas, Austin, Houston. Finally, when the affiliates were asked what the barriers they had for building LEED certified about 48 % of the reasons were cost as shown in figure 15.

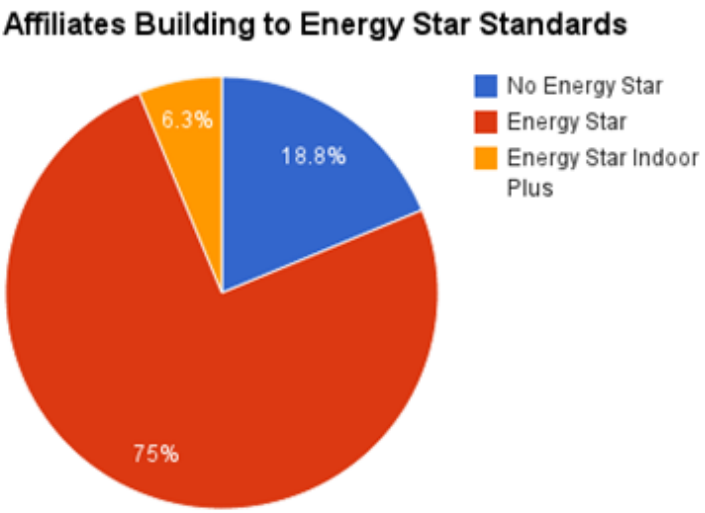


Figure 14. Habitat Affiliates in Texas using Energy Star

The second most common answer was lack of information or knowledge about LEED. The next step was to call the Texas chapters of USGBC to find out if they were working with any Habitat for Humanity affiliates, and all of the chapters said no. One chapter talked about having a volunteer event by sending members to go build for a day with Habitat. When talking with some of the affiliates that build all of their homes to LEED standards, the biggest reason they were able to build to those standards was finding grants and discounts to not increase the cost of the house.

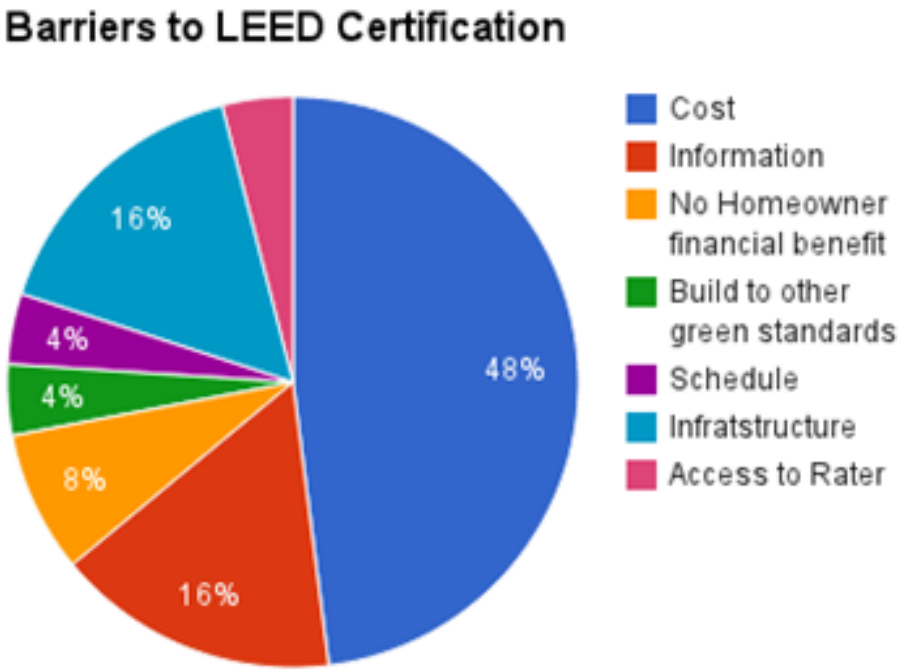


Figure 15. Barriers for Texas Affiliates to obtaining LEED for Home's Certification

A few of the affiliates have plans for a home, which meets LEED standards, so they can build in batches. One affiliate mentioned because they build in batches the

affiliate is able to get enough grants and discounts so there is not an extra cost to them for building process.

Overall from talking with HFH affiliates their barriers to building LEED were:

- Cost
- Knowledge of Green building practices
- Constructability
- Access to Green Raters

ANALYSIS OF SCORECARDS

Innovation and Design

The first category focuses on the design of the home, and uses additional points to encourage innovation. All of the homes had a preliminary meeting for LEED. 83% of the affiliates took it a step further and had an integrated project team. Out of all of the homes only 18% had someone on their team that is LEED accredited, and these homes are also HFH homes. This is probably due to the fact that this is seen as an unnecessary cost the affiliates have to pocket. The two affiliates that did receive points might have had already had a LEED accredited person on staff. The production homes did not have an integrated project team but they did have a design charrette, and two affiliates did this as well.

Part of the design process is designing for innovation, and designing the house to accommodate solar panels earns a credit. Less than 20% of all the homes were designed to accommodate solar panels, and the homes that did were HFH homes. These affiliates could have had solar panels donated to them, so they built the house with that in mind. It

is also possible they just built the house to accommodate solar panels if the home owner wanted them in the future.

Another feature of a good design is making sure the products used will last as long as possible. All of the homes had a durability plan, and all the homes had a third party verify the plan. Habitat is concerned about how the materials they use last for the home owner, because this reduces the overall cost to the home-owner. The results for 1.1-2.3 are shown in Table 1.

Table 1

Innovation and Design Credits

Innovation and Design	All	A	P	TC	NTC
1. Integrated Project Planning					
1.1 Preliminary Rating	8	6	4	6	2
1.2 Integrated Project Team	4	3	1	2	2
1.3 Professional Credential with Respect to LEED for Homes	2	1	1	2	0
1.4 Design Charrette	7	4	3	6	1
1.5 Building Orientation for Solar Design	2	1	1	1	1
2. Durability Management Process					
2.1 Durability Planning	8	6	4	6	2
2.2 Durability Management	8	6	4	6	2
2.3 Third Party Verification	9	6	3	7	2
3.Innovative or Regional					
3.1 Innovation 1	8	5	3	7	1
3.2 Innovation 2	6	3	3	6	0
3.3 Innovation 3	6	3	3	6	0
3.4 Innovation 4	4	2	2	4	0
Average of Total Scores					
ID	7	6.3	8.3	7.5	5.3

The scorecards are grouped All, A for affordable, P for production, TC for Texas Climate, and NTC for not Texas climate. This table shows the number of LEED scorecards that received points for Innovation and Design credits broken down by types of homes.

Location and Linkage

Location and Linkage focuses on community resources and building in developed areas. One of the options to get full credit is to build as part of a LEED Neighborhood Development. Depending on the criteria this could be very costly to a builder. Another reason none of the homes earned the credit is due to the fact some of the homes were built on single lots surrounded by development. When looking at site selection all of the homes, except for one Habitat home (91%), received the 2 points. Site selection comes down to the area each Habitat affiliate is building, and the affordability of the property. All but one Habitat home received points for credit 3.2 and 3.3. These homes were built on lots that had neighbors on all sides and had been previously developed. Many times this is the cheap land in the area, so this can be a more cost effective measure than the alternative. In addition, many larger cities do not have undeveloped lots or lots without neighbors on all sides of a vacant lot. This makes it easier for homes being developed in urban areas to earn the credits for Location and Linkage. All of the homes were built close enough to a city that they had existing water and sewer lines to connect to as well. Half of the homes had access to a community park for credit 6. If a builder is going specifically for low cost lots, a park is not always an option. The results for Location and Linkage are shown in Table 2.

Table 2

Location and Linkage Credit (a) 1.1-1.5, and (b) 2.1-2.3

Location and Linkage	All	A	P	TC	NTC
1. LEED ND					
1. LEED for Neighborhood Development	1	0	1	1	0
2. Site Selection					
2. Site Selection	9	6	3	7	2
3. Preferred Locations					
3.1 Edge Development	1	0	1	1	0
3.2 Infill	4	3	1	2	2
3.3 Previously Developed	4	3	1	2	2
4. Infrastructure					
4. Existing Infrastructure	9	6	3	7	2
5. Community Resources/					
5.1 Basic Community Resources / Transit	1	0	1	1	0
5.2 Extensive Community Resources / Transit	2	1	1	1	1
5.3 Outstanding Community Resources / Transit	3	2	1	2	1
6. Access to Open Space					
6. Access to Open Space	6	4	2	4	2
Average of Total Scores					
LL	5.8	6.5	3.5	4.5	9.5

Sustainable Sites

Since humans are using resources faster than they naturally replenish, having a home with a site that is as sustainable as possible is a requirement for building sustainably. All of the homes meet the prerequisite, and all but one Habitat home received a point for minimizing the land disturbance. They either built on a plot of land

that was 1/7th acre per unit or had a no disturbance zone. There are some affiliates that build in areas with tight spaces, so building on 1/7th acre may be standard. If there is enough space on site, it can be easy to block off no disturbance zones. One of the production homes earned the point for having a no disturbance zone.

Another aspect of having a sustainable site is the landscaping used. While all of the homes met the basic landscaping design for 2 points (2.2), only two homes, both Habitat, reduced the amount of conventional turf. One home reduced it by 41-60 % and the other by 20 % or less. Ninety one per cent of the homes planted drought tolerant plants. This potentially could be affordable if the builder is using indigenous plants that are also drought tolerant to keep cost down. While the homes had drought tolerant plants, none of the homes reduced their irrigation needs by 20 % or more. This is probably due to cost of equipment needed or keeping the conventional turf for most of the yard did not allow for a great impact. For credit 3, reducing the heat island effect, only 27% of homes received this credit. This could be due to a variety of reasons such as cost of providing plants to shade or material for sidewalks. Another reason could be the aesthetics of the light material for sidewalks might not be what home-owners like. The results for Sustainable Sites 1.1-3 are in Table 3 shown on page 40.

The fourth credit in Sustainable sites has to do with water management. Sixty-seven per cent of the Habitat homes received points for having at least 80 % of the lot be permeable, and none of the production homes received the point. Two of the affiliates also used vegetation as an erosion control for credit 4.2. This credit is probably easier for affiliates building on small lots to accomplish especially if the code requires a tree in the

yard. Very few homes seem to have received the credit, so potentially the size of their lot made the vegetation too expensive.

One Habitat home had their site designed for water run-off by a professional. None of the other homes received any points for this credit. A possible reason only one affiliate had a professional design the landscape is the designer could have volunteered their time, since normally it is out of the price range of a HFH affiliate. The production homes might not have found it to their economic benefits either.

Table 3.

Sustainable Sites Credit (a) 1.1-1.5, and (b) 2.1-2.3

Sustainable Sites	All	A	P	TC	NTC
1. Site Stewardship					
1.1 Erosion Controls During Construction	8	6	4	6	2
1.2 Minimize Disturbed Area of Site	5	4	1	3	2
2. Landscaping					
2.1 No Invasive Plants	8	6	4	6	2
2.2 Basic Landscape Design	8	5	3	6	2
2.3 Limit Conventional Turf	3	2	1	2	1
2.4 Drought Tolerant Plants	9	6	3	7	2
2.5 Reduce Overall Irrigation Demand by at Least 20%	1	0	1	1	0
3. Local Heat Island Effects					
3. Reduce Local Heat Island Effects	4	3	1	2	2

All of the homes received points for pest control. Many of these measures were focused on termite control. Termites are a problem in the Texas area and places with similar climates, so a builder would be wise to protect against them from the beginning.

50% of the Habitat homes were built on a 1/7th acre and one was built on 1/10th. One of the production homes was built on 1/10th an acre. The lot size is probably very dependent on where the home is being built. It is more common to have a small lot in Los Angeles, CA as it is to have one in the middle of nowhere Texas. The results for Sustainable Sites 4.1- 6.3 are shown in Table 4.

Table 4

Sustainable Sites Credits 4.1- 6.3 and the total for the section

Sustainable Sites	All	A	P	TC	NTC
4. Surface Water					
4.1 Permeable Lot	2	1	1	1	1
4.2 Permanent Erosion Controls	2	1	1	1	1
4.3 Management of Run-off from Roof	2	1	1	1	1
5. Nontoxic Pest Control					
5. Pest Control Alternatives	9	6	3	7	2
6. Compact Development					
6.1 Moderate Density	3	2	1	2	1
6.2 High Density	2	1	1	2	0
6.3 Very High Density	1	0	1	1	0
Average of Total Scores					
SS	9.8	9.2	11	9.1	12

Water Efficiency

Water efficiency seems to be the most difficult area for Habitat affiliates to receive points. The only points any of the affiliates received were for low flow faucets, showers, and toilets. The production homes received those points as well as points for a high efficiency irrigation system, and having a third party inspect it. This seems to be a category where cost plays a large factor in the points. It is not economically feasible for

affiliates to install a rainwater harvesting system or a gray water reuse system. Cost and location could be prohibitive of the municipal recycled water system. This hypothesis is also based on the fact none of the production homes had these features either. This could be because the manufacturer did not think it had a high benefit to cost ratio. The results for Water Efficiency are shown in Table 5.

Table 5

Water Efficiency Credits

Water Efficiency	All	A	P	TC	NTC
1. Water Reuse					
1.1 Rainwater Harvesting System	1	0	1	1	0
1.2 Minimize Disturbed Area of Site	1	0	1	1	0
1.3 Use of Municipal Recycled Water System	1	0	1	1	0
2. Irrigation System					
2.1 No Invasive Plants	1	0	1	1	0
2.2 Basic Landscape Design	1	0	1	1	0
2.3 Limit Conventional Turf	6	3	3	6	0
2.4 Drought Tolerant Plants	6	3	3	6	0
2.5 Reduce Overall Irrigation Demand by at Least 20%	1	0	1	1	0
3. Indoor Water Use					
3.1 High-Efficiency Fixtures and Fittings	8	5	3	7	1
3.2 Very High Efficiency Fixtures and Fittings	9	6	3	7	2
Average of Total Scores					
WE	7.1	5.8	9.7	7.9	4.5

Energy and Atmosphere

All of the homes earned their energy and atmosphere points by taking the route of EA 1, EA 7, and EA 11. The Habitat homes on average received better HERS scores

than the production homes. This also held true when only using similar climate zones. The results for Energy and Atmosphere are shown in Table 6.

Table 6

Energy and Atmosphere Credits

Energy and Atmosphere	All	A	P	TC	NTC
1. Optimize Energy Performance					
1.1 Performance of Energy Star for Homes	8	6	4	6	2
1.2 Exceptional Energy Performance	17.8	17.1	19.3	17.9	17.5
7. Water Heating					
7.1 Efficient Hot Water Distribution	2	1	1	2	0
7.2 Pipe Insulation	2	1	1	2	0
11. Residential Refrigerant					
11.1 Refrigerant Charge Test	0	0	0	0	0
11.2 Appropriate HVAC Refrigerants	8	5	3	7	1
Average of Total Scores					
EA	19.9	19.3	21.3	19.8	20.5

Only two homes earned points for an efficient hot water distribution system, while four received points for insulating the pipes. All the homes had a test to determine if the refrigerant was properly charged in the air condition system. All but three homes received a point for having refrigerants that minimize impact on the environment. Only 33 % of the homes in a non-Texas climate region earned this point, where 86 % of those in Texas climate regions earned it. This could be due to the lack of an air conditioning unit, which is not necessary in more northern climates. The other path is specific upgrades to the Energy Star requirement. The builders probably received more points by

going with a HERS rating over installing specific upgrades to the Energy Star minimum. A reason for this could be that a home could have upgrades in one area that go beyond the highest point level, with increased energy efficiency, but not have maximum points in another area with the same energy savings. Another possibility if it is easier to go the HERS route over Energy Star upgrades is the points could be disproportionately distributed with respect to energy savings

Materials and Resources

All of the homes had a waste factor of at most 10 %. Half of the affiliates received points for having detailed framing plan. Those same affiliates also received points for a detailed cut list. All of the production homes received a point for framing efficiency, and five of the Habitat affiliates received multiple points. One Habitat affiliate out of all of the homes received points for panel construction. A number of affiliates are using panel construction due to the time and cost reduction.

Credit 2.1 is a prerequisite and every home meets the standard. Every single home received at least some points for environmentally preferred products. The Habitat homes averaged a higher score than the production homes.

All of the homes meet the prerequisite of determining the local options to divert the waste from landfills and documenting the diversion rate. For Credit 3.2 only half of the Habitat affiliates and none of the production homes received points for reducing or diverting waste. A reason some builders did not do this could be the cost of diverting the waste, if there is not a local recycling center. All of the homes meet the prerequisite of determining the local options to divert the waste from landfills and documenting the

diversion rate. For Credit 3.2 only half of the Habitat affiliates and none of the production homes received points for reducing or diverting waste. A reason some builders did not do this could be the cost of diverting the waste, if there is not a local recycling center. The results for Materials and Resources are shown in Table 7.

Table 7

Materials and Resources Credits

Materials and Resources	All	A	P	TC	NTC
1. Material-Efficient Framing					
1.1 Framing Order Waste Factor Limit	8	6	4	6	2
1.2 Detailed Framing Documents	3	2	1	1	2
1.3 Detailed Cut List and Lumber Order	3	2	1	1	2
1.4 Framing Efficiencies	9	6	3	7	2
1.5 Off-site Fabrication	1	0	1	1	0
2. Environmentally Preferable Products					
2.1 FSC Certified Tropical Wood	8	6	4	6	2
2.2 Environmentally Preferable Products	9	6	3	7	2
3. Waste Management					
3.1 Construction Waste Management Planning	8	6	4	6	2
3.2 Construction Waste Reduction	3	2	1	1	2
Average of Total Scores					
MR	7.9	7.8	8	6.4	13.3

Indoor Environmental Air Quality

One of the reasons environmentally preferable products matter is the impact they have on the indoor air quality. This category looks at the indoor air quality of the homes, so the home-owners do not have to worry about their homes making them sick. The results for EQ credits 1.1-5.3 are in Table 8, shown on page 46. There was only one

home who installed the Energy Star Indoor Air Package. The home received full points on all of the additional credits except for 8.2, indoor contamination control. This is probably due to the cost of needed for these points, as well as the measures being above and beyond the simple and decent features. The rest of the homes chose to take the path of specific items to earn points.

Table 8

Indoor Environmental Quality Credits 1.1-5.3

Indoor Environmental Quality	All	A	P	TC	NTC
1. ENERGY STAR with IAP					
1. ENERGY STAR with Indoor Air Package	2	1	1	1	1
2. Combustion Venting					
2.1 Basic Combustion Measures	8	6	4	6	2
2.2 Enhanced Combustion Venting Measures	8	5	3	7	1
3. Moisture Control					
3. Moisture Load Control	1	0	1	1	0
4. Outdoor Air Ventilation					
4.1 Basic Outdoor Air Ventilation	8	6	4	6	2
4.2 Enhanced Outdoor Air Ventilation	3	2	1	2	1
4.3 Third Party Testing	6	3	3	6	0
5. Local Exhaust					
5.1 Basic Local Exhaust	8	6	4	6	2
5.2 Enhanced Local Exhaust	4	3	1	2	2
5.3 Third-Party Performance Testing	7	4	3	6	1

All of the homes had upgraded combustion venting, and 100% of the Habitat homes received the maximum number of points for venting. None of the homes received

points for moisture control, which is probably due to the cost of an extra dehumidifying system.

Three of the eligible six (50%) Habitat homes earned points for the upgraded exterior ventilation system, and one (9%) received the point for a third party verification. None of the production homes had the upgraded ventilation system, but they were all verified by a third party. This is very similar to the results for 5.2 and 5.3. All of the Habitats installed the upgraded exhaust for the bathroom and only two had a third party certify it. The production homes did not have the upgraded system, but did have the system verified by a third party. This is not unexpected, because the Habitat probably sees a third party rater as an extra expense that is not worth it.

When looking at credit 6.1-6.3, all of the Habitat homes meet the prerequisite of room by room load calculations, but only one had the amount of return vents required to earn the point. All of the production homes meet the prerequisite and had the return air vents as well, but only two were third party verified. These points are probably more costly than what Habitat is willing to spend, and potentially the verification is expensive with only two production homes receiving it.

Sixty per cent of the production homes used the better air filters, as well as three (50%) HFH homes. Two Habitat homes even received credit 7.3 for best filter. This is another point that is potentially not out of the price range for Habitat because nearly all the homes made at least some type of upgrade. The results for EQ credits 6.1-10.4 are in Table 9 and Table 10, both shown on page 48.

Table 9

Indoor Environmental Quality Credits C.1-7.2

Indoor Environmental Quality	All	A	P	TC	NTC
6. Distribution of Space Heating and Cooling					
6.1 Room-by-Room Load Calculations	8	6	4	6	2
6.2 Return Air Flow / Room by Room Controls	6	3	3	6	0
6.3 Third-Party Performance Test / Multiple Zones	3	1	2	3	0
7. Air Filtering					
7.1 Good Filters	8	6	4	6	2
7.2 Better Filters	5	3	2	5	0
7.3 Best Filters	2	1	1	1	1

Table 10

Indoor Environmental Quality Credits 8.1-10.4

Indoor Environmental Quality	All	A	P	TC	NTC
8. Contaminant Control					
8.1 Indoor Contaminant Control during Construction	8	5	3	7	1
8.2 Indoor Contaminant Control	6	3	3	6	0
8.3 Preoccupancy Flush	2	1	1	2	0
9. Radon Protection					
9.1 Radon-Resistant Construction in High-Risk Areas	1	1	0	0	1
9.2 Radon-Resistant Construction in Moderate-Risk Areas	3	2	1	2	1
10. Garage Pollutant Protection					
10.1 No HVAC in Garage	8	6	4	6	2
10.2 Minimize Pollutants from Garage	6	3	3	6	0
10.3 Exhaust Fan in Garage	1	0	1	1	0
10.4 Detached Garage or No Garage	3	2	1	2	1
Average of Total Scores					
EQ	11.9	11.2	13.3	11.4	13.5

All but one home received credit for sealing up the permanent vents during construction. This is a low cost point it just takes a little bit more time, but for Habitat it could minimize the time cost by having all of the volunteers help seal the vents. None of the Habitat affiliates received points for indoor contaminant control; this is probably due to the cost required. The production homes all received a point for having a shoe rack; this is probably the most cost effective way to achieve the point.

Radon is a toxic gas that can be a problem for home-owners, and especially in certain areas. 100% of the HFH homes met the prerequisite of protecting against radon for the high risk areas. 33% of the affiliates are in locations that are not in danger, but took the extra step to protect the home. This could be a point that affiliates see as not being worth the risk to the home-owner.

To minimize the spread of any toxic fumes the production homes took the step to seal off the garage from the inside, while all of the Habitat affiliates had detached garages or no garage. It is common practice for Habitat homes to not have a garage. There are affiliates who do provide garages many times it is because of the city code.

Awareness and Education

Education and awareness is a strength for Habitat for Humanity, because one of the core values is teaching home buyers how to be responsible home owners. Habitat wants the home owners to know how their homes work and how to maintain their home. Due to this value it is quite easy for the affiliate to give home owners packets of information about the home. Multiple affiliates provide a walk through about the home, its features, and how to maintain it already.

Credit 1.2 is fairly easy to for an affiliate to earn because of the way the system is set-up. Home owners are required to go to trainings in order to earn their home. Credit 1.3 requires publicizing the LEED home. The points awarded for publicizing LEED by the affiliate if done properly could be an easy point, due to the fact that volunteers are working on the home every week. This allows for the volunteers could be educated about LEED while on-site. Also, the affiliate could tie in LEED to its advertising.

None of the homes received a point for AE 2, which is most likely due to the fact that the point is awarded building managers for multifamily homes. Everything required for the building manager to have is a prerequisite for section when provided to the home-owner. The results for Awareness and Education are shown in Table 11.

Table 11

Awareness and Education Credits

Awareness and Education	All	A	P
1. Education of the Home-owner or Tenant			
1.1 Basic Operations Training	12	7	5
1.2 Enhanced Training	6	6	0
1.3 Public Awareness	9	4	5
2. Education of Building Manager			
2. Education of Building Manager	0	0	0
Average of Total Points			
AE	1.3	1.4	1.0

CHAPTER V

CONCLUSIONS

SUMMARY

The Habitat for Humanity affiliates in Texas want to build the best home for their homeowners as they can, but they are limited to a small budget. This is because the home must be affordable to the homeowner, and any additional cost up front the affiliate must cover. Most of the affiliates are building to Energy Star standards; however some affiliates will not be able to meet the new Energy Star 3.0 standards. A large number of points for LEED for Homes come from Energy Star standards. From the 15 affiliates who completed the survey the barriers for making the jump from Energy Star to LEED for Homes certification are:

- cost
- knowledge of Green building practices
- constructability
- access to green raters

Then looking at the scorecards for homes built by other HFH affiliates and a production homebuilder there were noticeable strengths and weaknesses for HFH affiliates.

The strengths from the LEED scorecards for the HFH affiliates were:

- The integrated project team
- building in dense areas

- The homes HERS score
- homeowner education

The weaknesses from the LEED scorecards for the HFH affiliates were:

- third-party raters
- Water-efficiency
- Energy Indoor Air Quality package

As long as an affiliate is building to Energy Star Standards, the jump to LEED certification is not too far away. Once Energy Star is met, the majority of the requirements for LEED are then based on the building site location and environmental measures. Affiliates building in urban areas will have an easier earn points for LEED easier than the more rural affiliates. This is because the urban affiliates are more likely to build in areas with community resources nearby and have the site surrounded by land that was previously developed.

FUTURE RESEARCH

Some of the options for future research are set out in this section. These options are:

- Computerization of evaluation of scorecards- Currently all of the data must be recorded by hand, so a computer program which extracts the data from the scorecards would make the process more efficient.
- Expand to national- Currently the survey of barriers to LEED certification was only completed in Texas, so this could expand to other affiliates across the nation.

- LEED scorecards for homes that have not obtained LEED certification for benchmarking- The best way to determine the gap between LEED certified homes and non-certified homes is to have a LEED scorecard filled out for homes that are not LEED certified.
- Compare LEED for Homes with NAHB from the homeowner's perspective. - There was a study of a comparison of LEED for Homes to NAHB green building certification based on initial cost.

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APPENDIX I

SCORECARD RESULTS AND ANALYSIS

This appendix summarizes the scorecards for the LEED analysis. Table 12 shows the raw data for Innovation and Design of the LEED scorecard of production homes.

Table 12

Innovation and Design of the LEED Scorecard of Production Homes

Innovation and Design	1	2	3	4	5
1.1 Preliminary Rating	Y	Y	Y	Y	Y
1.2 Integrated Project Team	0	0	0	0	0
1.3 Professional Credential with Respect to LEED for Homes	0	0	0	0	0
1.4 Design Charrette	1	1	1	1	1
1.5 Building Orientation for Solar Design	0	0	0	0	0
2.1 Durability Planning	Y	Y	Y	Y	Y
2.2 Durability Management	Y	Y	Y	Y	Y
2.3 Third Party Verification	3	3	3	3	3
3.1 Innovation 1	1	1	1	1	1
3.2 Innovation 2	1	0.5	1	1	0.5
3.3 Innovation 3	0.5	1	0.5	0.5	1
3.4 Innovation 4	1	0	1	1	0
Final	7.5	6.5	7.5	7.5	6.5

Table 13 shows the raw data for Location and Linkage of the LEED scorecard of production homes.

Table 13

Location and Linkage of the LEED Scorecard of Production Homes

Location and Linkage	1	2	3	4	5
1. LEED for Neighborhood Development	0	0	0	0	0
2. Site Selection	2	2	2	2	2
3.1 Edge Development	0	0	0	0	0
3.2 Infill	0	0	0	0	0
3.3 Previously Developed	0	0	0	0	0
4. Existing Infrastructure	1	1	1	1	1
5.1 Basic Community Resources / Transit	0	0	0	0	0
5.2 Extensive Community Resources / Transit	0	0	0	0	0
5.3 Outstanding Community Resources / Transit	0	0	0	0	0
6. Access to Open Space	0	1	0	1	1
Final	3	4	3	4	4

Table 14 shows the raw data for Sustainable Sites of the LEED scorecard of production homes.

Table 14

Sustainable Sites of the LEED Scorecard of Production Homes

Sustainable Sites	1	2	3	4	5
1.1 Erosion Controls During Construction	Y	Y	Y	Y	Y
1.2 Minimize Disturbed Area of Site	0	0	0	0	1
2.1 No Invasive Plants	Y	Y	Y	Y	Y
2.2 Basic Landscape Design	2	2	2	2	2
2.3 Limit Conventional Turf	0	0	0	0	3
2.4 Drought Tolerant Plants	2	2	2	2	2
2.5 Reduce Overall Irrigation Demand by at Least 20%	0	0	0	0	0
3. Reduce Local Heat Island Effects	0	0	1	0	0
4.1 Permeable Lot	0	0	0	0	0
4.2 Permanent Erosion Controls	0	0	0	0	0
4.3 Management of Run-off from Roof	0	0	0	0	0
5. Pest Control Alternatives	1.5	1.5	1.5	1.5	1.5
6.1 Moderate Density	0	0	0	0	0
6.2 High Density	0	0	0	0	3
6.3 Very High Density	0	0	0	0	0
Final	5.5	5.5	6.5	5.5	12

Table 15 shows the raw data for Water Efficiency of the LEED scorecard of production homes.

Table 15

Water Efficiency of the LEED Scorecard of Production Homes

Water Efficiency	1	2	3	4	5
1.2 Minimize Disturbed Area of Site	0	0	0	0	0
2.1 No Invasive Plants	0	0	0	0	0
2.2 Basic Landscape Design	0	0	0	0	0
2.3 Limit Conventional Turf	3	3	3	3	3
2.4 Drought Tolerant Plants	1	1	1	1	1
2.5 Reduce Overall Irrigation Demand by at Least 20%	0	0	0	0	0
3.1 High-Efficiency Fixtures and Fittings	1	1	1	1	1
3.2 Very High Efficiency Fixtures and Fittings	2	2	2	2	2
Final	7	7	7	7	7

Table 16 shows the raw data for Energy and Atmosphere of the LEED scorecard of production homes.

Table 16

Energy and Atmosphere of the LEED Scorecard of Production Homes

Energy and Atmosphere	1	2	3	4	5
1.1 Performance of Energy Star for Homes	Y	Y	Y	Y	Y
1.2 Exceptional Energy Performance	12	12	15	17	15
7.1 Efficient Hot Water Distribution	0	0	0	0	0
7.2 Pipe Insulation	0	0	0	0	0
11.1 Refrigerant Charge Test	Y	Y	Y	Y	Y
11.2 Appropriate HVAC Refrigerants	1	1	1	1	1
Final	13	13	16	18	16

Table 17 shows the raw data for Materials and Resources of the LEED scorecard of production homes.

Table 17

Materials and Resources of the LEED Scorecard of Production Homes

Materials and Resources	1	2	3	4	5
1.1 Framing Order Waste Factor Limit	Y	Y	Y	Y	Y
1.2 Detailed Framing Documents	0	0	0	0	0
1.3 Detailed Cut List and Lumber Order	0	0	0	0	0
1.4 Framing Efficiencies	1	1	1	1	1
1.5 Off-site Fabrication	0	0	0	0	0
2.1 FSC Certified Tropical Wood	Y	Y	Y	Y	Y
2.2 Environmentally Preferable Products	3	3	3	3	3
3.1 Construction Waste Management Planning	Y	Y	Y	Y	Y
3.2 Construction Waste Reduction	0	0	0	0	0
Final	4	4	4	4	4

Table 18 shows the raw data for Materials and Resources of the LEED scorecard of production homes, up to and including section 7. Table 19 shows the same information from section 8 to 10.

Table 18

Materials and Resources of the LEED Scorecard of Production Homes (Section 1 – 7)

Indoor Environmental Quality	1	2	3	4	5
1. ENERGY STAR with Indoor Air Package	0	0	0	0	0
2.1 Basic Combustion Measures	Y	Y	Y	Y	Y
2.2 Enhanced Combustion Venting Measures	1	1	1	1	1
3. Moisture Load Control	0	0	0	0	0
4.1 Basic Outdoor Air Ventilation	Y	Y	Y	Y	Y
4.2 Enhanced Outdoor Air Ventilation	0	0	0	0	0
4.3 Third Party Testing	1	1	1	1	1
5.1 Basic Local Exhaust	Y	Y	Y	Y	Y
5.2 Enhanced Local Exhaust	0	0	0	0	0
5.3 Third-Party Performance Testing	1	1	1	1	1
6.1 Room-by-Room Load Calculations	Y	Y	Y	Y	Y
6.2 Return Air Flow / Room by Room Controls	1	1	1	1	1
6.3 Third-Party Performance Test / Multiple Zones	0	2	0	0	2
7.1 Good Filters	Y	Y	Y	Y	Y
7.2 Better Filters	0	1	1	0	1
7.3 Best Filters	0	0	0	0	0

Table 19

Materials and Resources of the LEED Scorecard of Production Homes (Section 8 - 10)

Indoor Environmental Quality	1	2	3	4	5
8.1 Indoor Contaminant Control during Construction	1	1	1	1	1
8.2 Indoor Contaminant Control	1	1	1	1	1
8.3 Preoccupancy Flush	0	0	0	0	0
9.1 Radon-Resistant Construction in High-Risk Areas	N	N	N	N	N
9.2 Radon-Resistant Construction in Moderate-Risk Areas	0	0	0	0	0
10.1 No HVAC in Garage	Y	Y	Y	Y	Y
10.2 Minimize Pollutants from Garage	2	2	2	2	2
10.3 Exhaust Fan in Garage	0	0	0	0	0
10.4 Detached Garage or No Garage	0	0	0	0	0
Final	8	11	9	8	11

Table 20 shows the raw data for Awareness and Education of the LEED scorecard of production homes.

Table 20

Awareness and Education of the LEED Scorecard of Production Homes

Awareness and Education	1	2	3	4	5
1.1 Basic Operations Training	Y	Y	Y	Y	Y
1.2 Enhanced Training	0	0	0	0	0
1.3 Public Awareness	1	1	1	1	1
2. Education of Building Manager	0	0	0	0	0
Final	1	1	1	1	1

Table 21 shows the raw data for Innovation and Design of the LEED scorecard of HFH homes.

Table 21

Innovation and Design of the LEED Scorecard of HFH homes

Innovation and Design	1	2	3	4	5	6
1.1 Preliminary Rating	Y	Y	Y	Y	Y	Y
1.2 Integrated Project Team	1	1	1	0	1	1
1.3 Professional Credential with Respect to LEED for Homes	1	0	0	0	0	1
1.4 Design Charrette	0	0	1	0	0	1
1.5 Building Orientation for Solar Design	0	1	0	0	0	1
2.1 Durability Planning	Y	Y	Y	Y	Y	Y
2.2 Durability Management	Y	Y	Y	Y	Y	Y
2.3 Third Party Verification	3	3	3	0	3	3
3.1 Innovation 1	1	0.5	0	1	0	1
3.2 Innovation 2	0	0	0	1.5	0	1
3.3 Innovation 3	0	0	0	0	0	0
3.4 Innovation 4	0	0	0	0	0	0
Final	6	5.5	5	2.5	4	9

Table 22 shows the raw data for Location and Linkage of the LEED scorecard of HFH homes.

Table 22

Location and Linkage of the LEED Scorecard of HFH homes

Location and Linkage	1	2	3	4	5	6
1. LEED for Neighborhood Development	0	0	0	0	0	0
2. Site Selection	2	2	2	0	2	2
3.1 Edge Development	0	0	0	0	0	0
3.2 Infill	2	2	2	0	2	2
3.3 Previously Developed	1	1	1	0	1	1
4. Existing Infrastructure	1	1	1	1	1	1
5.1 Basic Community Resources / Transit	0	0	0	0	0	0
5.2 Extensive Community Resources / Transit	0	2	0	0	0	0
5.3 Outstanding Community Resources / Transit	3	0	3	0	3	3
6. Access to Open Space	0	1	1	0	0	1
	9	9	10	1	9	10

Table 23 shows the raw data for Sustainable Sites of the LEED scorecard of HFH homes.

Table 23

Sustainable Sites of the LEED Scorecard of HFH homes

Sustainable Sites	1	2	3	4	5	6
1.1 Erosion Controls During Construction	Y	Y	Y	Y	Y	Y
1.2 Minimize Disturbed Area of Site	1	1	1	0	1	1
2.1 No Invasive Plants	Y	Y	Y	Y	Y	Y
2.2 Basic Landscape Design	0	2	2	2	2	2
2.3 Limit Conventional Turf	0	1	0	0	0	0
2.4 Drought Tolerant Plants	2	2	2	2	0	2
2.5 Reduce Overall Irrigation Demand by at Least 20%	0	0	0	0	0	0
3. Reduce Local Heat Island Effects	0	1	1	0	0	0
4.1 Permeable Lot	0	3	0	2	1	2
4.2 Permanent Erosion Controls	0	1	0	0	0	1
4.3 Management of Run-off from Roof	0	0	2	0	0	0
5. Pest Control Alternatives	2	2	1	1.5	1	1
6.1 Moderate Density	2	0	2	0	0	2
6.2 High Density	0	0	0	3	0	0
6.3 Very High Density	0	0	0	0	0	0
Final	7	13	11	10.5	5	11

Table 24 shows the raw data for Water Efficiency of the LEED scorecard of HFH homes.

Table 24

Water Efficiency of the LEED Scorecard of HFH homes

Water Efficiency	1	2	3	4	5	6
1.2 Minimize Disturbed Area of Site	0	0	0	0	0	0
2.1 No Invasive Plants	0	0	0	0	0	0
2.2 Basic Landscape Design	0	0	0	0	0	0
2.3 Limit Conventional Turf	0	0	0	0	0	0
2.4 Drought Tolerant Plants	0	0	0	0	0	0
2.5 Reduce Overall Irrigation Demand by at Least 20%	0	0	0	0	0	0
3.1 High-Efficiency Fixtures and Fittings	1	0	1	1	1	0
3.2 Very High Efficiency Fixtures and Fittings	4	4	4	4	4	4
Final	5	4	5	5	5	4

Table 25 shows the raw data for Energy and Atmosphere of the LEED scorecard of HFH homes.

Table 25

Energy and Atmosphere of the LEED Scorecard of HFH homes

Energy and Atmosphere	1	2	3	4	5	6
1.1 Performance of Energy Star for Homes	Y	Y	Y	Y	Y	Y
1.2 Exceptional Energy Performance	20.5	14.5	20.5	15.5	22.5	19.5
7.1 Efficient Hot Water Distribution	2	0	0	0	2	0
7.2 Pipe Insulation	1	0	0	1	1	1
11.1 Refrigerant Charge Test	Y		Y	Y	Y	Y
11.2 Appropriate HVAC Refrigerants	1	0	1	1	0	1
Final	24.5	19.5	21.5	17.5	25.5	21.5

Table 26 shows the raw data for Materials and Resources of the LEED scorecard of HFH homes.

Table 26

Materials and Resources of the LEED Scorecard of HFH homes

Materials and Resources	1	2	3	4	5	6
1.1 Framing Order Waste Factor Limit	Y	Y	Y	Y	Y	Y
1.2 Detailed Framing Documents	0	1	1	0	1	0
1.3 Detailed Cut List and Lumber Order	0	1	1	0	1	0
1.4 Framing Efficiencies	2.5	3	3	0	2	0
1.5 Off-site Fabrication	0	0	0	4	0	0
2.1 FSC Certified Tropical Wood	Y	Y	Y	Y	Y	Y
2.2 Environmentally Preferable Products	6	4	8	8	3	8
3.1 Construction Waste Management Planning	Y	Y	Y	Y	Y	Y
3.2 Construction Waste Reduction	0	1.5	3	0	0	2.5
Final	8.5	10.5	16	12	7	10.5

Table 27 shows the raw data for Indoor Environmental Quality of the LEED scorecard of HFH homes up to Section 8.2. Table 28 shows the raw data from Section 8.3 to 10.4. Table 29 shows the raw data for Awareness and Education of the LEED scorecard of HFH homes.

Table 27

Indoor Environmental Quality of the LEED Scorecard of HFH homes

Indoor Environmental Quality	1	2	3	4	5	6
1. ENERGY STAR with Indoor Air Package	0	0	13	0	0	0
2.1 Basic Combustion Measures	Y	Y	Y	Y	Y	Y
2.2 Enhanced Combustion Venting Measures	2	2	0	2	2	2
3. Moisture Load Control	0	0	0	0	0	0
4.1 Basic Outdoor Air Ventilation	Y	Y	Y	Y	Y	Y
4.2 Enhanced Outdoor Air Ventilation	2	0	2	2	0	2
4.3 Third Party Testing	0	0	0	1	0	0
5.1 Basic Local Exhaust	Y	Y	Y	Y	Y	Y
5.2 Enhanced Local Exhaust	1	1	1	1	1	1
5.3 Third-Party Performance Testing	0	0	1	1	0	0
6.1 Room-by-Room Load Calculations	Y	Y	Y	Y	Y	Y
6.2 Return Air Flow / Room by Room Controls	0	0	0	0	1	0
6.3 Third-Party Performance Test / Multiple Zones	0	0	0	0	0	0
7.1 Good Filters	Y	Y	Y	Y	Y	Y
7.2 Better Filters	1	0	0	0	1	1
7.3 Best Filters	0	0	2	2	0	0
8.1 Indoor Contaminant Control during Construction	1	1	0	1	1	1
8.2 Indoor Contaminant Control	0	0	0	0	0	0

Table 28

Indoor Environmental Quality of the LEED Scorecard of HFH homes Section 8.3 to 10.4

Indoor Environmental Quality	1	2	3	4	5	6
8.3 Preoccupancy Flush	1	0	0	0	1	1
9.1 Radon-Resistant Construction in High-Risk Areas			Y	Y	Y	Y
9.2 Radon-Resistant Construction in Moderate-Risk Areas	1	1	0	0	0	0
10.1 No HVAC in Garage	Y	Y	Y	Y	Y	Y
10.2 Minimize Pollutants from Garage	0	0	0	2	0	0
10.3 Exhaust Fan in Garage	0	0	0	1	0	0
10.4 Detached Garage or No Garage	3	3	0	0	3	3
Final	12	8	19	13	10	11

Table 29

Awareness and Education of the LEED Scorecard of HFH homes

Awareness and Education	1	2	3	4	5	6
1.1 Basic Operations Training	Y	Y	Y	Y	Y	Y
1.2 Enhanced Training	1	1	1	0	1	1
1.3 Public Awareness	0	1	1	0	1	0
2. Education of Building Manager	0	0	0	0	0	0
Final	1	2	2	0	2	1

APPENDIX II

AFFILIATE SURVEY

This appendix summarizes the data from the affiliate survey. Table 30 shows the survey results for the affiliates in Texas for HaH for questions 1 to 3 for first two affiliates.

Table 30

The Texas affiliates survey raw data Question 1 to 3 for Affiliate 1 and 2

Questions	Affiliate 1	Affiliate 2
1. Does your affiliate have a green or sustainable building policy?	Yes	No
If yes what is the policy and does it meet LEED requirements?	Energy star	energy star
2. Do you work with the local USGBC chapter?	No	No
3. What are some barriers to certifying homes with LEED for your affiliate?	Cost, having standards available	Cost, only build 2 houses a year and construction department does not necessarily see benefit

Table 31 shows the survey results for the affiliates in Texas for HaH for questions 1 to 3 for the third and fourth affiliates.

Table 31

The Texas affiliates survey raw data Question 1 to 3 for Affiliate 3 and 4

Questions	Affiliate 3	Affiliate 4
1. Does your affiliate have a green or sustainable building policy?	Yes	Yes
If yes what is the policy and does it meet LEED requirements?	Recommendation from Habitat International, energy star, 1st of year air quality improvement, drawing plans for water conservation	smart housing policy, green certificate, energy star
2. Do you work with the local USGBC chapter?	No	no
3. What are some barriers to certifying homes with LEED for your affiliate?	None	Austin smart housing, cost, infrastructure cost,

Table 32 shows the survey results for the affiliates in Texas for HaH for questions 1 to 3 for next two affiliates. Table 33 shows the survey results for the affiliates in Texas for HaH for questions 1 to 3 for next two affiliates. Table 34 shows the survey results for the affiliates in Texas for HaH for questions 1 to 3 for next two affiliates. Table 35 shows the survey results for the affiliates in Texas for HaH for questions 1 to 3 for next two affiliates. Table 36 shows the survey results for the affiliates in Texas for HaH for questions 1 to 3 for next two affiliates. Table 37 shows the survey results for the affiliates in Texas for HaH for questions 1 to 3 for the fifteenth affiliate.

Table 32

The Texas affiliates survey raw data Question 1 to 3 for Affiliate 5 and 6

Questions	Affiliate 5	Affiliate 6
1. Does your affiliate have a green or sustainable building policy?	Yes	Yes
If yes what is the policy and does it meet LEED requirements?	energy star	energy star new construction, deconstruction
2. Do you work with the local USGBC chapter?	No	don't know
3. What are some barriers to certifying homes with LEED for your affiliate?	water management, add additional step would hurt their schedule, information	not looked into it yet

Table 33

The Texas affiliates survey raw data Question 1 to 3 for Affiliate 7 and 8

Questions	Affiliate 7	Affiliate 8
1. Does your affiliate have a green or sustainable building policy?	No	no, used to build to LEED standards, energy star standard
If yes what is the policy and does it meet LEED requirements?	59% above code sealing, energy star	
2. Do you work with the local USGBC chapter?	not one	not one
3. What are some barriers to certifying homes with LEED for your affiliate?	cost,	lost the grant for incentives, could not find rater, not incentive for homeowners

Table 34

The Texas affiliates survey raw data Question 1 to 3 for Affiliate 9 and 10

Questions	Affiliate 9	Affiliate 10
1. Does your affiliate have a green or sustainable building policy? If yes what is the policy and does it meet LEED requirements?	no, incorporate as much green ideas as possible, last 6 have been energy star	No, energy star standard 2.5, fee for HVAC 1200
2. Do you work with the local USGBC chapter?	not one	no, not aware of chapter
3. What are some barriers to certifying homes with LEED for your affiliate?	cost, and man power, volunteer ability to perform work	not looked into serious because more than they can do

Table 35

The Texas affiliates survey raw data Question 1 to 3 for Affiliate 11 and 12

Questions	Affiliate 11	Affiliate 12
1. Does your affiliate have a green or sustainable building policy? If yes what is the policy and does it meet LEED requirements?	no, energy star, recycling, indoor air plus (EPA)	no, energy star, recycling
2. Do you work with the local USGBC chapter?	No	no
3. What are some barriers to certifying homes with LEED for your affiliate?	waste management, education on LEED,	cost

Table 36

The Texas affiliates survey raw data Question 1 to 3 for Affiliate 13 and 14

Questions	Affiliate 13	Affiliate 14
1. Does your affiliate have a green or sustainable building policy?	no, sealed envelope	no
If yes what is the policy and does it meet LEED requirements?		
2. Do you work with the local USGBC chapter?	no	no
3. What are some barriers to certifying homes with LEED for your affiliate?	initial cost, 60-65000 total cost	cost

Table 37

The Texas affiliates survey raw data Question 1 to 3 for Affiliate 15

Questions	Affiliate 15
1. Does your affiliate have a green or sustainable building policy?	No
If yes what is the policy and does it meet LEED requirements?	
2. Do you work with the local USGBC chapter?	No
3. What are some barriers to certifying homes with LEED for your affiliate?	Cost